INSECTS AFFECTING GREENHOUSE PLANTS

BY ARTHUR GIBSON AND W.A.ROSS

DOMINION OF CANADA

DEPARTMENT OF AGRICULTURE

PUBLICATION 695

(Revision of Bulletin No. 7—New Series)

Published by direction of the Hon. JAMES G. GARDINER, Minister of Agriculture,
Ottawa, May, 1940

SCIENCE SERVICE

Director, J. M. Swaine, B.S.A., M.Sc., Ph.D., F.R.S.C.

DIVISION OF ENTOMOLOGY

Dominion Entomologist and Chief of Division ..... Arthur Gibson, LL.D., F.R.S.C., F.R.E.S., F.E.S.A.

Systematic Entomology ..... J. H. McDunnough, M.A., Ph.D., F.R.S.C.

Field Crop Insect Investigations ..... H. G. Crawford, B.S.A., M.S.

Forest Insect Investigations ..... J. J. de Gryse, Ph. Cand.

Fruit Insect Investigations ..... W. A. Ross, B.S.A.

LABORATORIES

Annapolis Royal, N.S. ..... Fruit Insect Investigations: A. D. Pickett, B.S.A., M.Sc., in charge.

Fredericton, N.B. ..... Forest Insect Investigations: R. E. Balch, B.S.A., M.Sc., in charge.
Field Crop Insect Investigations: R. P. Gorham, B.S.A., in charge.
Fruit Insect Investigations: C. W. Maxwell, B.S.A., in charge.

Berthierville, P.Q. ..... Forest Insect Investigations: L. Daviault, B.S.A., M.Sc., Ph.D., in charge.

Hemmingford, P.Q. ..... Fruit Insect Investigations: C. E. Petch, B.S.A., in charge.

Ottawa, Ont. ..... Canadian Insect Pest Survey: C. R. Twinn, B.S.A., M.Sc., in charge.
Forest Insect Investigations: E. B. Watson, A.R.C.Sc., D.I.C., in charge.
Vegetable Insect Investigations: A. G. Dustan, B.S.A., M.Sc., in charge.
Stored Product Insect Investigations: H. E. Gray, B.A., B.S., M.S., in charge.

Belleville, Ont. ..... Parasite Investigations: A. B. Baird, B.S.A., M.Sc., in charge.

Vineland Station, Ont. ..... Fruit Insect Investigations: W. A. Ross, B.S.A., in charge.

Simcoe, Ont. ..... Fruit Insect Investigations: J. A. Hall, B.S.A., in charge.

Chatham, Ont. ..... Field Crop Insect Investigations: G. M. Stirrett, B.S.A., M.Sc., Ph.D., in charge.

Harrow, Ont. ..... Fruit Insect Investigations: W. E. van Steenburgh, B.Sc., M.A., Ph.D., in charge.

Brandon, Man. ..... Field Crop Insect Investigations: R. D. Bird, B.Sc., M.Sc., Ph.D., in charge.

Winnipeg, Man. ..... Forest Insect Investigations: H. A. Richmond, B.Sc., M.Sc., in charge.

Indian Head, Sask. ..... Forest Insect Investigations: L. O. T. Peterson, B.Sc., M. Sc., acting in charge.

Saskatoon, Sask. ..... Field Crop Insect Investigations: K. M. King, B.S., M.Sc., in charge.

Lethbridge, Alta. ..... Field Crop Insect Investigations: H. L. Seamans, B.Sc., M.Sc., in charge.

Agassiz, B.C. ..... Field Crop Insect Investigations: R. Glendenning, in charge.

Kamloops, B.C. ..... Livestock Insect Investigations: G. A. Mail, B.Sc., M.Sc., in charge.
Field Crop Insect Investigations: E. R. Buckell, B.A., in charge.

Vancouver, B.C. ..... Forest Insect Investigations: W. G. Mathers, B.S.A., M.Sc., in charge.

Victoria, B.C. ..... Fruit Insect Investigations: W. Downes, in charge.

Vernon, B.C. ..... Forest Insect Investigations: G. R. Hopping, B.Sc., M.Sc., in charge.
Fruit Insect Investigations: J. Marshall, B.S.A., M.Sc., Ph.D., in charge.

PUBLICATION 695 ISSUED MAY, 1940
Farmers' Bulletin No. 94 Revision
DOMINION OF CANADA—DEPARTMENT OF AGRICULTURE

INSECTS AFFECTING GREENHOUSE PLANTS

By ARTHUR GIBSON and W. A. ROSS

DIVISION OF ENTOMOLOGY
SCIENCE SERVICE

Published by Authority of the Hon. James G. Gardiner, Minister of Agriculture,
Ottawa, Canada

Price 25 cents

15M-3702-5:40

CONTENTS

97773—1¼

Insects Affecting Greenhouse Plants

By Arthur Gibson and W. A. Ross

INTRODUCTION

Every grower of plants under glass has, at some time or other, experienced losses owing to the presence of destructive insects. Roses, chrysanthemums, carnations, primroses, ferns, snapdragons, cucumbers, lettuce, and many other plants, are every year attacked by various kinds of leaf-eating, sucking or other insects, resulting in losses which amount, annually, to many thousands of dollars. Much of this loss may be prevented if growers will adopt the remedies which are recommended in this bulletin.

When a plant is attacked, the grower should observe how the insect feeds, as such fact will help materially in deciding upon the proper remedy to apply. Injurious insects may be divided, roughly, into two classes, by the nature of their mouth parts, namely, (1) biting insects which bite and chew their food, such as caterpillars, and (2) sucking insects which suck up their food by means of their beaks, such as the aphids, the true bugs, the scale insects, etc. If the insect is a biting one, a stomach poison, such as lead arsenate, is usually applicable, but if the species is a sucking one, such poisons would be useless because the insect would insert its beak through the poison and reach a safe feeding place beneath. For sucking insects, therefore, contact insecticides are recommended, such for instance as preparations containing nicotine.

Certain insects such as aphids and white fly are best controlled by fumigation with a tobacco preparation or hydrocyanic acid gas. Boring or root destroying insects require a different treatment.

In this bulletin information is included which should assist the grower to recognize the various kinds of insect pests with which his plants may become infested. The remedies for the insects discussed have been found of value and if the grower will follow these carefully, he will undoubtedly keep the pests under control and thereby protect his plants.

In addition to insects destructive in greenhouses, chapters are also included on animal pests, other than insects, and on useful or beneficial insects.

RECOMMENDATIONS FOR CONTROLLING GREENHOUSE INSECTS

GENERAL RECOMMENDATIONS

Injury by insects in greenhouses can be kept down to insignificant proportions by prompt and proper treatment. The grower working among his plants every day—watering them, cutting flowers, picking off dead leaves, etc., has every opportunity of observing insect pests before they become destructive. The old adage "a stitch in time saves nine" should be taken to heart by the grower, and in working among his plants he should develop the habit of setting aside or marking any insect-infested plant and treating it before the pest has time to spread through the house. Incipient infestations of leaf-eating caterpillars may frequently be detected from a few leaves having been fastened together by the caterpillars, and may sometimes be stamped out by the prompt destruction of the infested material.

The drawings for the illustrations used in this Bulletin were made by Frank C. Hennessey, Artist, Division of Entomology.

It is important, particularly during the summer months, that weeds should not be permitted to grow as they will attract from the outside insects which may develop and cause serious injury to crops grown later in autumn and winter. Weeds in the neighbourhood outside should also be kept down to a minimum, and wherever possible a barren strip, four to six yards wide and preferably covered with cinders or concrete should be maintained immediately around the houses. Crop refuse and rubbish of all kinds should not be allowed to accumulate. The prompt destruction of such debris will do away with conditions frequently suitable for the harbouring of insect pests.

In selecting soil for the greenhouse, care should be taken to see that it is free from soil-infesting insects, such as cutworms, white grubs and wireworms. If there is reason to believe that the soil is infested with destructive insects, it should be sterilized, where possible, with steam (see page 77).

As several serious greenhouse insects, such as the chrysanthemum midge and the rose midge, have been introduced into Canadian greenhouses on plants brought in from the United States, florists would be well advised to examine carefully new stock imported at any time, and should forward for diagnosis to the Dominion Entomologist, Dominion Department of Agriculture, Ottawa, Ont., or the Dominion Entomological Laboratory, Vineland Station, Ont., any plant or portion of a plant showing indications of the presence of insects.

Where practicable, there is no more valuable preventive measure than that of screening the ventilators and doors with 14-mesh, rustless wire cloth. Screening will exclude the adults of several serious pests, such as the tarnished plant bug, the greenhouse leaf-tyer and the corn ear worm, which when well established are difficult to control. Top and side ventilator screens have already been installed in several Canadian greenhouses and the probabilities are that in a comparatively short time such screening will be considered essential greenhouse equipment.

INSECTICIDES AND THEIR APPLICATION

SPRAYERS AND DUSTERS.—Various types of hand sprayers and hand dusters, specific information concerning which may be obtained from the manufacturers, are used in greenhouses for applying insecticides. A sprayer should be capable of maintaining a pressure of at least 100 pounds and should be equipped with an angle nozzle or nozzles. A duster should throw a uniform cloud of dust and should be sufficiently compact to permit its use in narrow greenhouse walks.

Where practicable, dusting has several advantages over spraying. Dusts can be applied more rapidly and efficiently and their residues are more easily washed off plants than those of sprays.

The following insecticides have been found of value under greenhouse conditions:

LEAD ARSENATE.—This is a standard stomach poison for combating chewing insects such as caterpillars. As a spray it may be used at a strength of 2 pounds to 40 gallons of water, or 4 ounces to 5 gallons of water; as a dust it may be mixed with hydrated lime—1 pound to 4 pounds hydrated lime. Factory-mixed dusts containing lead arsenate may be purchased from insecticide dealers. One of the most useful mixtures for greenhouse plants is composed of 85 parts of dusting sulphur and 15 parts of lead arsenate.

PARIS GREEN.—This also is an effective stomach poison, but it cannot be used with safety in water alone. As a spray it may be used at a strength of ½ pound to 40 gallons of water (1 ounce to 5 gallons of water), adding at least twice its weight of hydrated lime to prevent arsenical burning. For dusting purposes it should be mixed with ten times its weight of hydrated lime.

Paris green is much more efficient than lead arsenate as a poison in baits, for such pests as cutworms and sowbugs.

NICOTINE EXTRACTS.—Nicotine is a contact insecticide commonly used as a spray or fumigant (page 9) for controlling aphids and some other insects against which stomach poisons are useless. It may be purchased in the form of 40 per cent nicotine sulphate or as "free" nicotine.

Nicotine extracts should be used at the strength recommended by the manufacturers, and soap should always be added to the diluted sprays at the rate of 2 pounds to 40 gallons or 4 ounces to 5 gallons.

NICOTINE DUSTS.—Contact dust preparations, made by impregnating hydrated lime or some other superfine material with nicotine, are sold by commercial firms for combating aphids and other sucking insects. Generally speaking a 3 per cent nicotine dust is required.

A satisfactory home-made dust may be prepared by mixing $3\frac{3}{4}$ pounds of nicotine sulphate (40 per cent) with 50 pounds of hydrated lime in a mixer consisting of a tight barrel placed horizontally on a stand so that it may be revolved by hand. In the side of the barrel a hole about six inches square is cut and a hinged lid attached. The requisite quantity of lime is placed in the barrel and the nicotine sulphate is poured over the lime. A few stones about the size of golf balls should also be put in the barrel to prevent the lime from caking and to ensure even mixing. The barrel should then be revolved for about five minutes until the nicotine is thoroughly mixed. The dust may then be poured directly into the duster or into air-tight cans. The stones may be removed by pouring the dust through wire netting.

SOAP WASHES.—Solutions of whale oil soap, linseed oil soap, or laundry soaps are useful contact insecticides, but, as they may injure tender foliage, it is advisable to wash off the soaps with water about two hours after they are applied.

PYRETHRUM EXTRACTS.—Various commercial pyrethrum sprays are on the market and are being used extensively for the control of greenhouse insects. In spraying with them the manufacturer's directions should be followed.

DERRIS.—The roots of tropical plants of the genera *Derris* and *Lonchocarpus* possess a valuable insecticidal material known as rotenone. Derris in the form of powdered root may be employed as a spray at the rate of 1 to 2 pounds to 40 gallons of water or as a dust diluted with about six times its own weight of talc or clay. Commercial rotenone extracts may be purchased and should, of course, be used according to the manufacturer's directions. Although destructive to many kinds of insects, derris (or rotenone) is relatively harmless to most higher animals, including man.

THIOCYANATES.—During the past 10 or 15 years, research workers have demonstrated the value in insect control of certain of the synthetic organic insecticides known as thiocyanates. Low concentrations of these thiocyanates have been shown to have a high degree of effectiveness in controlling aphids, mealybugs, red spider, chrysanthemum midge, thrips, etc. The thiocyanates are reported to have marked chemical stability and not to deteriorate in storage. In contact with insects they affect the nervous system causing paralysis and death. Proprietary insecticides containing thiocyanates for use against pests of greenhouse plants are available on the market. In using them, the directions of the manufacturer should be followed.

HYDROCYANIC ACID GAS FUMIGATION

Such insects as whiteflies, plant lice and thrips, may be controlled by fumigating with hydrocyanic acid gas. The earlier system of generating the gas, by dropping potassium or sodium cyanide into pots containing diluted sulphuric acid, has been largely supplanted, in recent years, by the much simpler and more convenient method afforded by calcium cyanide. With this material no

carefully measured quantities of acid and water and no pots are required—the cyanide is simply scattered over the walks and on exposure to the air gives off the hydrocyanic acid gas.

Dosage.—Owing to the fact that the degree of tightness in greenhouses varies so much, no general recommendations can be made as to the required amount of calcium cyanide which should be used for each 1,000 cubic feet of space. Each grower must find out for himself just what dosage is efficient and at the same time safe to the plants. For houses with "butted" glass, an initial dose of $\frac{1}{4}$ ounce per 1,000 cubic feet may be used; for tight greenhouses with "lapped" glass it is advisable to begin with $\frac{1}{8}$ ounce. If the initial dosage is not sufficient, the amount may be increased, *e.g.* from $\frac{1}{4}$ ounce to $\frac{1}{2}$ ounce, until satisfactory results are secured.

How to Use Calcium Cyanide.—The first step in fumigation is, of course, to determine the cubic capacity of the house (see page 9). The required amount of calcium cyanide should be weighed out, the ventilators and all other openings should be closed as tightly as possible, and, *as soon as it is dark, but*

FIG. 1.—White fly adults on cucumber leaf killed by fumigation (authors' illustration).

not before this, the cyanide should be scattered thinly and evenly on the walks from the end farthest from the door to the other end, after which the doors should be closed and locked securely from the outside and a notice posted stating that fumigation is in progress. In the morning shortly *before* sunrise, the house should be opened up and aired.

Fumigation should be done when there is little or no wind, and during fumigation the house temperature should not be lower than 55 degrees F. or higher than 70 degrees F. As high humidity increases the risk of cyanide injury to the plants, and as water on the walks tends to decrease the efficiency of the gas, the house should not be watered for 12 to 24 hours preceding the fumigation. Furthermore, in order to prevent the formation of moisture on the leaves, the temperature should be rising and not falling during fumigation.

Calcium cyanide is extremely poisonous to animals and humans; every care should be taken in its use.

HYDROCYANIC ACID GAS AND COPPER SPRAYS.—As plants sprayed with Bordeaux mixture may be severely injured by hydrocyanic acid gas, only basic copper fungicides should be employed before fumigation. Bordeaux mixture, however, may be used after fumigation.

NICOTINE FUMIGATION

Such insects as aphids may be controlled by fumigation with nicotine. Tobacco leaves or stems have been used to a considerable extent for this purpose, but are not as safe and reliable as the commercial preparations of nicotine, which are made in the form of liquids, papers, powders and cones, for fumigating greenhouses. In using these the manufacturer's directions should be followed carefully.

NEW FUMIGANTS

In recent years, a number of new materials have been employed experimentally and to a limited extent commercially, as greenhouse fumigants, but until more investigational work has been done to establish their value and limitations, and to develop suitable methods for their use in commercial greenhouses, their general use cannot be recommended.

Among the most promising of these fumigants are: (1) naphthalene[1], the fumes of which are more toxic to the red spider mite than most fumigants, (2) dichloroethyl ether[2], reported to have a wide range of toxicity to many insects, and (3) methyl bromide, which up to the present time has been used chiefly as a fumigant for dormant plants, but which is suitable under certain conditions for growing plants.

METHOD OF COMPUTING THE CUBIC CONTENTS OF A GREENHOUSE

The simplest method of computing the cubic capacity of an even-span greenhouse is to add height to gutter and height to ridge and divide by 2; multiply this by the width of the greenhouse; then multiply the result by the

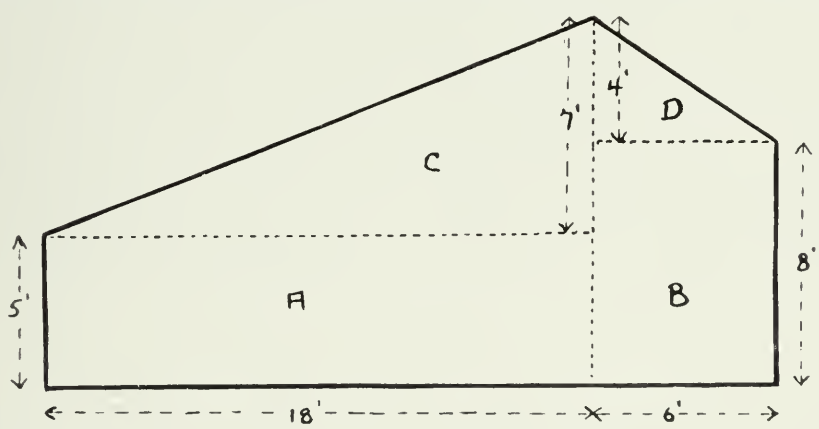


FIG. 2.—End view of three-quarter span house to illustrate method of computing cubic contents.

length of the greenhouse. For example, supposing a house has the following dimensions—height to gutter 6 feet, height to ridge 12 feet, width of greenhouse 30 feet, length of greenhouse 100 feet—the cubic capacity is computed in the following way:—

$$\left\{\frac{(\text{Height to gutter} + \text{height to ridge})}{2} \times \text{width}\right\} \times \text{length}$$

$= 6 + 12 \div 2 = 9$ feet; $9 \times 30 = 270$ sq. feet; $270 \times 100 = 27{,}000$ cubic feet.

[1] Bull. No. 326, Mass. Agr. Expt. Sta., December, 1935
[2] Cont. Boyce Thompson Institute 10, 47-56, 1938.

In ascertaining the cubic contents of a three-quarter span house, the first step is to make a rough diagram of the end view (fig. 2) and divide it into two rectangles and two triangles as shown in the figure. Then compute the area of each rectangle by multiplying the base by the height, and the area of each triangle by multiplying half the base by the perpendicular. Add the areas together and multiply the total by the length of the greenhouse. For example, in a house 100 feet long and with other dimensions as shown in fig. 2: A, $18 \times 5 = 90$ square feet; B, $6 \times 8 = 48$ square feet; C, $7 \times 9 = 63$ square feet; D, $4 \times 3 = 12$ square feet. $A + B + C + D = 213$ square feet. $213 \times 100 = 21{,}300$ cubic feet—the cubic capacity of the house.

BIOLOGICAL CONTROL

The use of natural enemies known as parasites for the control of injurious insects in greenhouses is a comparatively recent development, but results secured with certain pests indicate that the near future may see many important developments in this field. Special investigations in this connection are being carried on at the Dominion Parasite Laboratory, Belleville, Ontario. Parasites are particularly useful against insect pests for which no satisfactory chemical or artificial control is available and in situations where use of the standard chemical controls is impracticable such as:—

(1) Where fumigation is unsafe or undesirable due to the proximity of living quarters to a greenhouse or conservatory.
(2) Where mixed crops are grown and include plants easily injured by chemicals or gases.
(3) In greenhouses that are not sufficiently tight to ensure satisfactory fumigation.
(4) In large open ranges of glass that cannot conveniently or economically be closed for the fumigation of small areas.

Parasites may also be used in many cases in conjunction with fumigation and other control methods to further the destruction of the pests and thus eliminate or reduce the frequency of additional treatments required.

LEAF-EATING INSECTS

THE GREENHOUSE LEAF-TYER, *Phlyctœnia rubigalis* Gn.

The greenhouse leaf-tyer, a European insect, has increased to a serious extent in many greenhouses in Eastern Canada. The first Canadian record of injury by the caterpillars refers to an outbreak which occurred in a large greenhouse in Toronto, Ont. The actual year of introduction is not known, but it is thought that this was in 1896 or 1897. The leaf-tyer has since been found at other points in the Province of Ontario, and there are also reports of injury from various points in the Provinces of Alberta, Manitoba, Quebec, New Brunswick, and Nova Scotia. The species is doubtfully reported from the Province of British Columbia, but no records of injury therefrom are available. The insect was doubtless introduced into Canada from the United States where it has long been known as a pest of greenhouse plants.

DESCRIPTION AND HABITS

The Egg.—The egg is about one-half millimeter in width, round in outline, much flattened, slightly raised in centre, pearly-white, coarsely reticulated, and from its flattened appearance remarkably like that of the codling moth. Before hatching the black heads of the young larvæ are very apparent through

the shell. The eggs are laid on the undersides of the leaves either singly or several together forming a mass; in the latter case they overlap. Eggs kept under observation at Ottawa hatched in fourteen days.

The Larva or Caterpillar.—The larva, when it emerges from the egg, is in general appearance of a semi-translucent creamy-white colour, the body bearing long, whitish hairs. After feeding it is of a light greenish appearance. The young larvæ feed on the undersides of the leaves and eat little holes into the soft tissue. When at rest they curl the head and front segments around to the side of the body and, if disturbed, fall and hang suspended on silken threads. The larvæ have five stages or instars. They do not change very markedly when developing. At full growth they are about three-quarters of an inch in length. The upper surface is dark green, the sides and under surface paler. Longitudinal stripes are also present on the back.

FIG. 3.—Bed of marigold plants destroyed by the greenhouse leaf-tyer (after Gibson).

Larvæ in all stages of development have been found working at the same time and at various seasons. The generations undoubtedly overlap. The caterpillars feed almost entirely on the undersides of the leaves, eating away the soft green tissue and spoiling the appearance of the foliage. In the case of the mature larvæ conspicuous portions of the leaves are entirely eaten. The caterpillars are generally found within a slight silken web. In many instances two leaves are brought together and fastened by threads of silk, the larva feeding on the soft tissue on the underside of the upper leaf. Figure 3 shows the destruction of plants which frequently results from the work of the caterpillars. The bed of ageratum plants in a large greenhouse in eastern Ontario from which the plant in the illustration (figure 4) was obtained was completely destroyed by the larvæ. The separate leaf shows characteristic injury to the foliage of marigold. On the leaf several caterpillars at work may be observed.

When ready to pupate, the caterpillar simply folds over a portion of a leaf and fastens it with threads of fine white silk, or choosing a central portion of a leaf, draws down another leaf to serve as a covering and then changes to a pupa. The cocoon itself is very slight and is merely a web or covering of slender threads of white silk. The pupa in length is about three-eighths of an inch and in colour is shining brown, becoming darker with age. The length of the pupal stage is from seventeen to twenty days.

FIG. 4.—Leaf of marigold showing injury by the greenhouse leaf-tyer; caterpillars at work on leaf. Ageratum plant at right destroyed by caterpillars (after Gibson).

The Moth.—This is of a rusty-brown colour, the wings being crossed with darker lines. The hind wings are paler than the front wings. When at rest the moth measures three-eights of an inch at widest part and with the wings spread a little over five-eights of an inch. During the daytime the moths have the habit of resting on the undersides of leaves or in corners or other sheltered

places in the greenhouse. At night they are active, flying about among the plants.

From observations made at Ottawa during the winter months, from seventy to seventy-five days, approximately, elapsed from the time the eggs were laid until the resultant moths appeared. Under greenhouse conditions, therefore, there is time from the end of September until the end of May for at least three or possibly four generations.

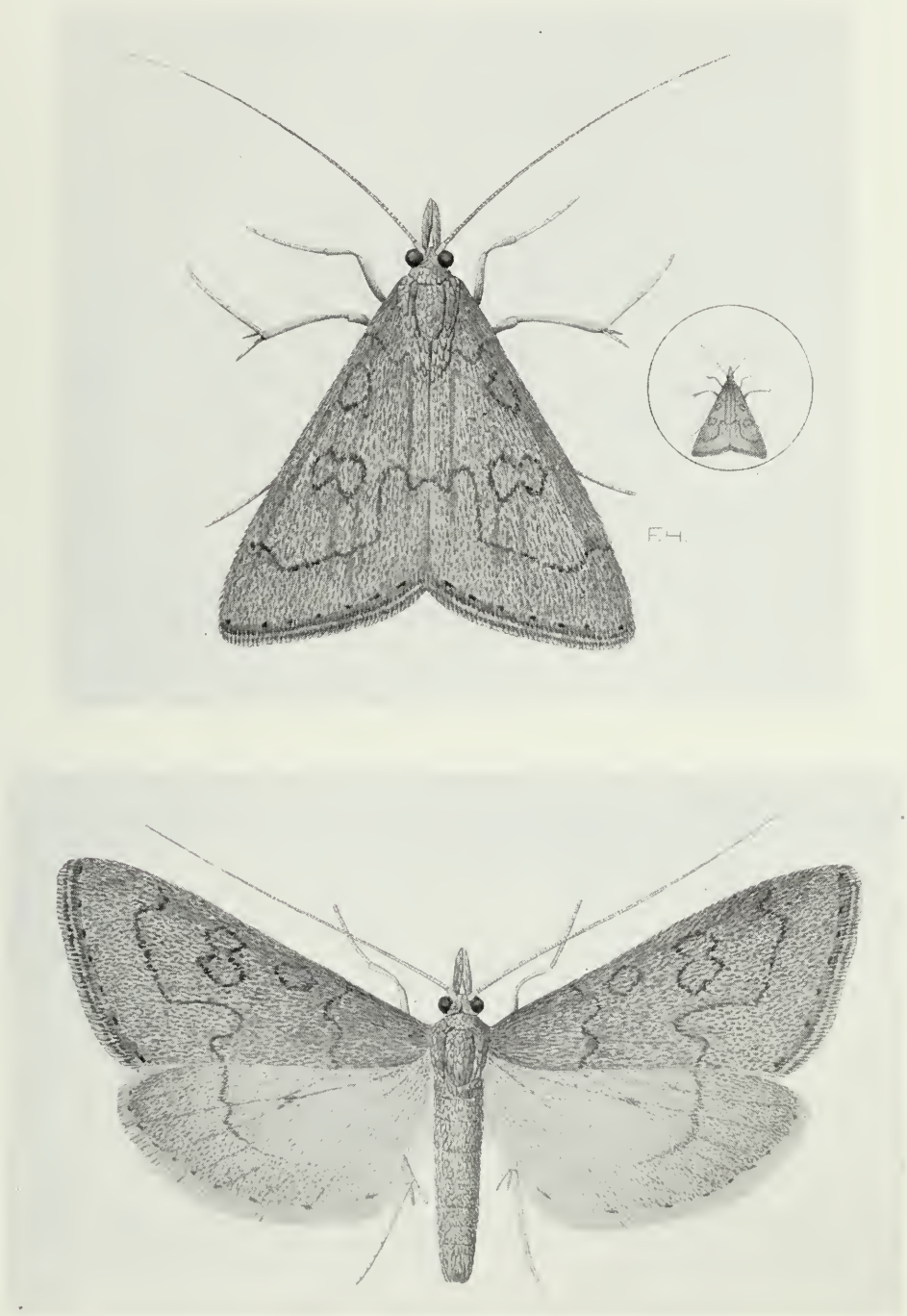


FIG. 5.—Moth of greenhouse leaf-tyer at rest and with wings spread; enlarged and natural size (original).

Food Plants.—In Canada, the larvæ have been destructive to cineraria, primula, snapdragon, ageratum, rose, chrysanthemum, marigold, calendula, geranium, aster, heliotrope, mignonette, sweet pea, fern, salvia, canna, azalea, cyclamen, wall-flower, violet, German ivy, tomato, cabbage and lettuce. In the United States, in addition to the plants mentioned above, the caterpillars have

attacked nodding thistle (Carduus), wandering jew, ground ivy, Kenilworth ivy, dahlia, justicia, anemone, matricaria, passiflora, plumbago, ruellia, tydæa, lobelia, veronica, lantana, deutzia, clover, strawberry, parsley, and cucumber. It will, therefore, be seen that almost any soft-leaved greenhouse plant is liable to be attacked.

Under outside conditions, this insect has caused injury to celery, tobacco, cabbage, sugar beet, spinach, nasturtium, begonia, carnation, and a few wild plants. Because of its importance as a pest of celery it is commonly called the celery leaf-tyer.

CONTROL

Serious outbreaks of this destructive insect may be prevented by adopting the following practices:—

(1) Screen the ventilators and doors as suggested on page 6 to exclude the moths.
(2) In working among the plants take time to examine any leaf which is skeletonized or which shows webbing, and if caterpillars are found destroy them by hand while still present in small numbers.
(3) At the first sign of an infestation, dust the plants thoroughly with 85-15 sulphur-lead arsenate dust, directing the dust upwards so that the underside of the foliage will be well coated.

In dealing with a heavy infestation, the undersides of the leaves should be dusted weekly with 85-15 sulphur-lead arsenate dust, and they should also be sprayed with a pyrethrum extract in between the applications of dust.

Light Traps.—It is well known that lights at night attract moths and other insects. One florist in Toronto, Ontario, whose house was infested with the greenhouse leaf-tyer kept a 200-watt nitrogen lamp burning all night, about two inches over a pan (18 inches in diameter) filled with water, on which sufficient coal oil was poured to cover the surface. The light was continued until the infestation was controlled.

THE FLORIDA FERN CATERPILLAR, *Callopistria floridensis* Gn.

The first occurrence of the Florida fern caterpillar in Canada was noted in September, 1915, in greenhouses at Weston, Ont. The caterpillars were found on some ferns imported from Chicago, and the insect had doubtless been introduced with such shipment. During the winter of 1915-16 opportunity was provided for studying the life-history of the insect and observing its habits. Since, the caterpillars have been found in destructive numbers in greenhouses in the Montreal district.

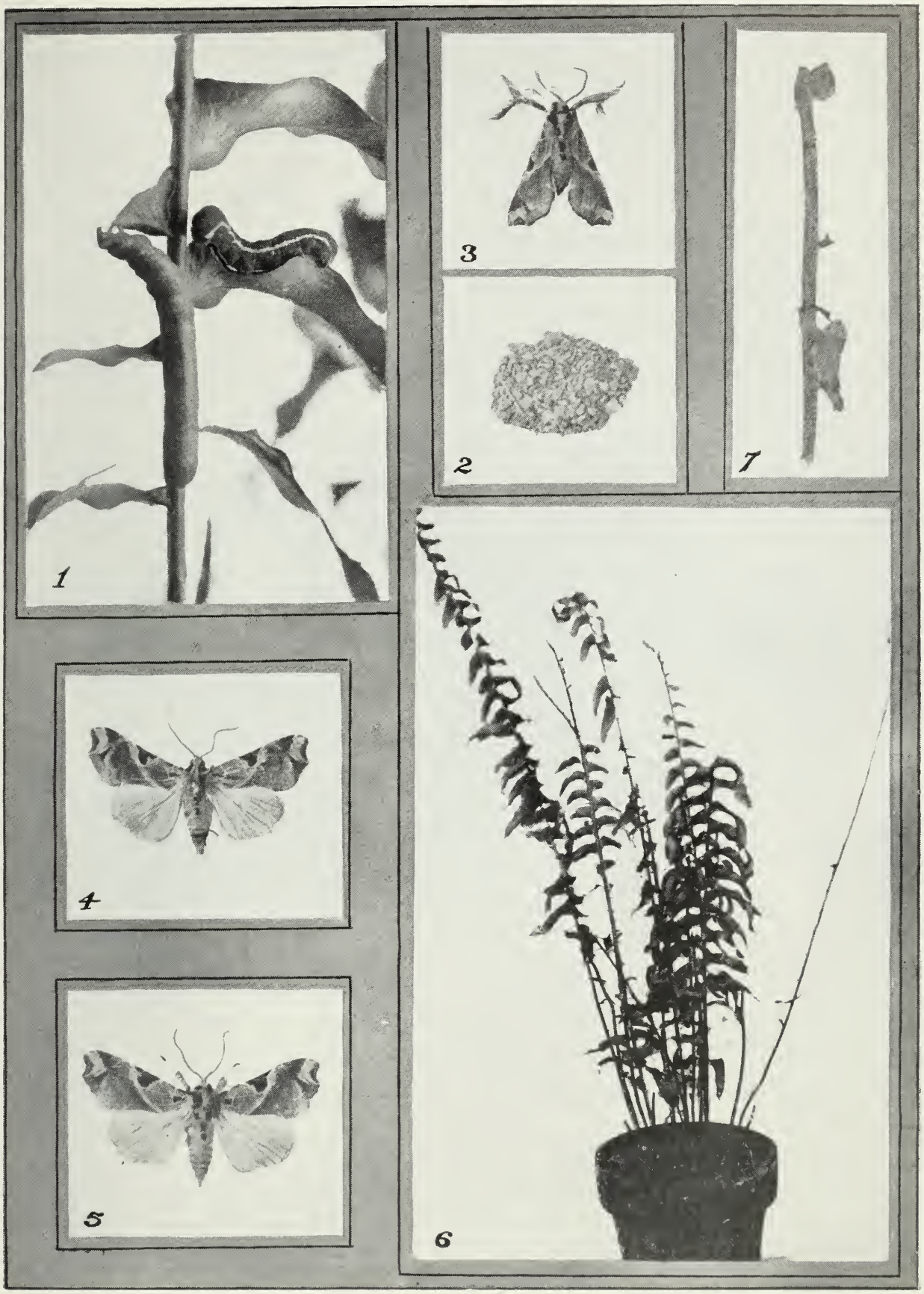
DESCRIPTION AND HABITS

The Egg.—It has not been possible so far to secure eggs of the moth, either by searching in greenhouses or from living moths kept under observation in captivity. Davis[1] describes the egg (laid in confinement) as "circular in section, about one-fiftieth of an inch in diameter, slightly flattened, ribbed longitudinally and transversely," and states that in colour it "is pale greenish with a faint yellowish tint, much resembling the colour of the new fern fronds." The same author states that in confinement the moths deposited their eggs singly on the under surface of the new leaves. Weiss[2] records an incubation period of from five to seven days.

The Larva or Caterpillar.—During January, February and March, 1916, several lots of larvæ representing various stages were received at Ottawa. At first the larva is pale green without markings. In the second stage, rather

[1] 27th Report State Entomologist of Illinois.
[2] Can. Ent. XLVII, 23.

PLATE I



THE FLORIDA FERN CATERPILLAR, *Callopistria floridensis* Gn.

FIG. 1.—Two forms of larvæ; 2, cocoon; 3, moth at rest; 4, female moth; 5, male moth; 6, Boston fern plant, showing injury by larvæ; 7, tip of frond of Boston fern destroyed by larvæ (after Gibson).

97773—3½

indistinct, pale whitish, longitudinal stripes appear on the body, which are more conspicuous in later stages. When mature the caterpillar is from about one and a quarter to one and a half inches in length. It is a beautiful larva and varies strikingly in colour, some specimens being brownish with a greenish tinge, others green and others again dull reddish, or dark reddish-brown. The longitudinal stripes on the body are still present, being more pronounced in some specimens than in others. Some of the larvæ have a conspicuous band, yellowish-white in colour, along either side, as indicated in plate I, fig. 1. In addition to the longitudinal stripes on the body, all specimens have a conspicuous dark-coloured band extending across the front of the thoracic shield, immediately behind the head, and this character should serve to determine the species.

The caterpillars are active feeders and when several occur on a single plant, they soon effect serious damage. Like other noctuid larvæ they prefer the young and tender leaves, but will readily attack the older and larger leaves, and even eat into the more tender portions of the stems. In an experimental breeding cage, one frond measuring 16 inches in length was entirely denuded, by one last stage caterpillar in four days. In the Weston outbreak investigated, the plants were indeed an unsaleable lot; in many cases the plants had been almost entirely defoliated. Many had been destroyed to the extent shown in plate I, fig. 6. At the height of the infestation from three to a dozen larvæ were shaken from a plant growing in a five-inch pot. When not feeding the caterpillars have the habit of resting on the stems chiefly towards the base of the plants.

When the caterpillar completes its growth, it leaves the plant and makes an earthen cocoon on the surface of the soil. The earth is held together by many strands of silk spun by the larva, which gives the structure considerable strength. The cocoon shown in plate I, fig. 2, is about natural size. The pupa inside the cocoon is reddish-brown in colour and in general appearance similar to that of the common garden cutworms. In about two weeks the moth emerges.

The Moth.—The moth is a rather striking species and quite different from any other form found in Canada. The wings in general are brown, with a darker velvety rather V-shaped costal area near the centre of the wings. Towards the apex of the wings and at the base of each wing the colour is also dark brown. Some examples are, in general, of a darker brown shade than others. The markings on the wings are shown in figs. 4 and 5, plate I. The bands across the forewings are whitish tinged with pink. The hind wings are of a uniform paler brown colour, lighter towards the base. The body corresponds in general to the colour of the wings. In the male there is a conspicuous widening of the antennæ near the head. The legs are conspicuously tufted. With the wings expanded the moth measures about one and one-quarter inches in width. Being nocturnal in habit they are seldom seen during the day.

Food Plants.—In the Weston, Ont., greenhouses, the ferns attacked were Boston, Whitmanii and Scottii and in the Montreal greenhouses the same varieties were attacked. Other varieties of ferns have also been recorded as being subject to injury.

CONTROL

Hand Picking.—Large numbers of the larvæ were destroyed by hand picking in the Weston houses. On occasions, the pots were shaken individually and caterpillars crushed with the foot as they dropped. In one of the Montreal houses the shaking of the caterpillars from the plants was done three times a week for about three months, but even this laborious method of control was not satisfactory.

Arsenical Mixtures.—Spraying with mixtures containing lead arsenate did not prove successful. When used in sufficient strength to destroy the cater-

pillars, a white deposit remained on the foliage which was difficult to remove even with forceful watering. Mixtures containing paris green, too, did not give satisfactory results.

Pyrethrum Insect Powder.—In one of the large Montreal houses, dusting with pyrethrum insect powder twice a week was found to give the best results. Two weeks after this remedy had been applied not a single caterpillar could be found. The following spray also proved effective:—

Fresh pyrethrum insect powder.....	$\frac{1}{2}$ pound
Common laundry soap.....	$\frac{1}{4}$ pound
Water	8 gallons

The soap should be dissolved in a small quantity of warm water after which the insect powder and water should be added to make up eight gallons of mixture. Applications should be made once a week for four or five weeks.

THE OBLIQUE-BANDED LEAF-ROLLER, *Archips (Cacoecia) rosaceana* Harris

This leaf-roller has frequently been recorded as causing injury in the greenhouse. The species has a wide distribution and out-of-doors is known to attack a variety of plants. It has not as yet, however, in Canada, developed into a

Fig. 6.—The work of a leaf-roller (after Gibson).

greenhouse pest of importance. Owing to its injuries in orchards in Nova Scotia, it has been discussed as an apple pest by Sanders and Dustan.[1]

DESCRIPTION AND HABITS

The Egg.—The egg is small, flat, of a pale greenish colour and a number are laid together, all forming a compact mass of an oval shape. Five egg masses collected outside in Nova Scotia had an average of 159 eggs per mass. The egg stage lasts about one week.

The Larva or Caterpillar.—The young caterpillar is of a pale yellow colour becoming darker yellow, yellowish-green and green as it develops. When mature it is about three-quarters of an inch in length, the colour of the back being dark green, the under portion lighter green. The head is black or dark brown. When fully fed it pupates within a folded leaf and in about three weeks the moth emerges.

[1] Bull. No. 16, Ent. Branch, Dom. Dept. Agr.

In addition to feeding upon the leaves, this caterpillar has the habit, also, of feeding on the buds and even the flower petals. Owing to its habit of rolling over a leaf, fastening this with threads of silk, and living mostly within such shelter, it is known popularly by the name of leaf-roller. When disturbed the caterpillar has the habit of wriggling backwards and dropping from the plant or hanging suspended on a silken thread.

The Moth.—The moth has a wing expanse of about one inch. The front wings are of a light brownish colour crossed with darker brown lines and three broad, oblique, dark brown bands. The hind wings are of a yellowish-orange colour, the basal area darker. The moths may be seen flying among the plants or resting on the framework of the house.

Food Plants.—This leaf-roller in greenhouses is known particularly as a pest of roses and carnations. Owing to the wide range of food plants upon which it feeds out-of-doors, other plants may, however, at times be attacked.

CONTROL

See under rose leaf-tyer, and orange tortrix.

Another species, of the same genus, known as *Archips (Cacoecia) rosana* Linn. has attacked the foliage of rose grown in a greenhouse in British Columbia. The adult moth is smaller than that of the oblique-banded leaf-roller, *Archips rosaceana* Harris, with darker wings and more prominent cross bandings. The apex of each of the upper wings is less pointed than in *A. rosaceana* Harris. In addition to British Columbia the insect is known to occur in the Eastern Provinces.

The caterpillar of *A. rosana* Linn. is a general feeder. Out-of-doors it is recorded as a pest of honeysuckle, hydrangea, dahlia, peony, raspberry and other plants. When mature it is in general much the same as that of the oblique-banded leaf-roller, about one-half inch in length and in colour greyish-green. The control measures mentioned under the rose leaf-tyer and the orange tortrix, should be equally effective against this species.

THE ROSE LEAF-TYER, *Archips (Cacoecia) parallela* Rob.

This insect on occasions has caused injury in greenhouses in the Province of Ontario. In 1899 and 1900, the caterpillars effected important damage at Hamilton, Ont., and an account of these infestations is given in the report of the Dominion Entomologist for the year 1900.

DESCRIPTION AND HABITS

The Larva or Caterpillar.—When full grown the caterpillar is about one inch long. In colour it is dull green, darker on the back. On the body are conspicuous white warts or tubercles, each of which bears a rather long hair.

Injury by the caterpillars was first noticed in June, 1899, and in 1900 the larvæ were present in conspicuous numbers from March until about the middle of October. The caterpillar feeds on the green foliage and like the greenhouse leaf-tyer, has the habit of drawing the leaflets together by means of silken threads and feeding inside such shelter. When it becomes full grown it spins a light cocoon among the leaves, two or three of which it gathers together. The pupal period of specimens bred at Ottawa, in 1900, was about nine or ten days.

The Moth.—The moth, which in a superficial way, closely resembles the well-known oblique-banded leaf-roller, measures from three-quarters of an inch to very nearly an inch in expanse of wings, and in greenhouses there are several broods in a season. The colour of the upper wings is a pale brown, crossed obliquely by three bands of a much darker shade, the central one of

which is clearly defined at its margins. The other two bands fill up the apical and basal areas of the wings. In many specimens the basal band is almost obliterated. The whole wing surface is loosely reticulated with indistinct basal lines. The under wings are paler than the upper.[1]

Food Plants.—The only plant attacked in greenhouses, so far as has been recorded, is the rose.

CONTROL

As a rule it should be practicable to control this species in greenhouses by picking and burning the infested leaves. Where necessary, hand picking should be supplemented by dusting the plants with 85-15 sulphur-lead arsenate.

THE ORANGE TORTRIX, *Tortrix citrana* Fern.

The orange tortrix, a well-known pest of citrus fruits in California, was found, in 1931, to be causing important injury in a large commercial greenhouse in Vancouver, B.C. A few years previous to this, the species had been reared from caterpillars found in a greenhouse at Ladysmith, B.C. Since 1931, further important infestations have occurred in other greenhouses in British Columbia, and the species is now well established in the province. The insect is apparently western in distribution, and doubtless the infestation in British Columbia was introduced on plants from a southern locality.

DESCRIPTION AND HABITS

The Egg.—The egg, about 1 mm. long and 0·5 mm. wide, is similar to that of other tortricid moths. It is deposited usually on the stems and upper and lower surfaces of the leaves of roses and other plants, in small irregular masses of from 10 to 30, the eggs overlapping one another like shingles on a roof. In British Columbia, W. Downes, in charge of the Dominion Entomological Laboratory at Victoria, has found egg masses on the framework and the glass of greenhouses. In colour the egg is pale yellowish. Eggs under observation hatched in from 10 to 15 days.

The Larva or Caterpillar.—The larva or caterpillar is very active and spins a considerable amount of silk. When young it is of a creamy-white colour, changing as it grows older to pale green. When mature, it is about half an inch long and varies in colour from greenish-white to dark grey or pale brown, with a brown head. No distinguishing marks are present. When full grown it is about half an inch in length.

The larval stage varies from three to four weeks according to temperature, humidity and abundance of food.

The Pupa.—When full grown the caterpillar changes to the pupal state within the larval nest, whether this be in the rolled portion of a leaf, or within a flower bud. The pupa, enclosed in a thin silken cocoon, is three-eighths of an inch in length, brown in colour, paler at the intersegmental folds. The pupal period is from 9 to 10 days.

The Moth.—The moth has an average wing expanse of about five-eighths of an inch. The front wings are of a light grey colour, sometimes a cinnamon or darker brown, crossed about the middle with a rather wide, irregular, dark brown band. There is also a brownish patch on the upper edge of each front wing, midway between this band and the apex. The hind wings are whitish, and the body greyish or brownish.

During the day time, the moths hide among the foliage. Mating takes place immediately after emergence from the pupa and eggs are deposited by the female within two or three days.

[1] Report of Ent. and Bot., Dom. Exp. Farms, 1900.

PLATE II

Injury by caterpillars of the orange tortrix. Figs. 1 and 2, to foliage of asparagus fern; 3 and 4, to foliage of rose (original).

Food Plants.—The caterpillars feed on the foliage of a number of different plants. In greenhouses in British Columbia, much damage has been done to asparagus fern, rose, wallflower, cyclamen, chrysanthemum and geranium. Not infrequently, the leaves of rose and other plants are rolled up and fastened with silk. Flower buds, too, are bored into and thus destroyed. Even the fruit of tomato has been destroyed by the caterpillars. In California, in addition to orange and other citrus fruits, the caterpillar is known to attack apricot, willow, oak, walnut, goldenrod, and in greenhouses, wandering jew, acacia, eucalyptus, lavender, Jerusalem cherry, cineraria, begonia, rose, geranium, etc.

CONTROL

Arsenicals.—A spray of lead arsenate has been used to good effect on geraniums kept for propagation purposes. For plants on which lead arsenate spray residue would be objectionable an 85-15 sulphur-lead arsenate dust could no doubt be employed effectively.

Hand Picking.—Infested portions of foliage should be hand picked and destroyed by burning, particularly when injury is first noticed.

HCN Fumigation.—This method of control, according to Mr. Downes' experience was not effective, except against the adult moth. Heavy doses are needed for the larvæ and such would be dangerous to mixed greenhouse crops.

Light Traps.—See page 14.

THE VARIEGATED CUTWORM, *Peridroma margaritosa* Haw.

This common and widely distributed cutworm is occasionally found in destructive numbers in greenhouses. The species is cosmopolitan in distribution and in Canada occurs almost everywhere. Out-of-doors, in one season alone, in Canada and the United States, crops having a market value of over two million dollars were destroyed by this cutworm.

DESCRIPTION AND HABITS

The Egg.—The eggs of cutworm moths are, in general, similar in appearance, being pale in colour, dome-shaped and less than one millimeter in diameter. If examined under a lens they are seen to be beautifully ribbed, the ribs being joined by indistinct cross-ridges. A single female moth lays several hundreds of eggs. These are clustered on the leaves of weeds, grasses, shrubs, etc.

The Larva or Caterpillar.—The variegated cutworm when mature is a large plump caterpillar measuring about two inches in length by one-fourth of an inch in width. It is variable in colour ranging from pale grey to almost a dull brown, some specimens with a greenish tinge. The body is mottled and streaked with dark brown or black and marked along the side with a conspicuous yellowish band. Between this band and the middle of the back is an interrupted stripe of velvety black blotches, bordered more or less with orange. Below this and above the yellowish band just mentioned is a series of blackish curved dashes on either side, one on each segment. Down the centre of the back is a rather thin yellowish stripe which is expanded into a spot in the middle of some of the central segments. These spots are nearly always present on segments four to seven and in some examples the stripe is widened into spots on one or two other segments.

This cutworm has been found attacking carnation, chrysanthemum, snapdragon, violet, etc., in greenhouses. The buds of carnations are eaten into as shown in fig. 7. Infrequently serious injury to chrysanthemums is reported, the cutworms attacking the heads and cutting off the florets. In the field and garden

it attacks freely all crops and even does much damage by climbing fruit trees, currant bushes, etc., and eating the leaves. These caterpillars are nocturnal in habit, hiding during the day just beneath the surface of the soil.

The Pupa.—When the caterpillar becomes full grown, it enters the earth and makes an earthen cell in which it changes to a brownish, or dull reddish pupa. In size, the pupa is about five-eighths of an inch long and about five-sixteenths of an inch in width at widest part; at the end are two short spines. The moth usually emerges from the pupa in about two weeks time.

FIG. 7.—Carnation buds eaten by the variegated cutworm (after Gibson).

The Moth.—The moth is also extremely variable. It expands from about an inch and a half to nearly two inches in width. The front wings are of some shade of brown, or reddish-brown, usually darker along the outer margin. Some specimens are more or less blotched with pale brownish-yellow, while in others the whole lower and central area of the wings is pale brownish-yellow. The centre of the hind wings is pearly-white, with a purplish reflection, the edges being bordered with brown.

The cutworm moths are also nocturnal in habit, being seldom seen during the day time. In the early evening they appear in search of the nectar of flowers.

CONTROL

Poisoned Bran Mixture.—The following mixture is the one which is now used most extensively for the destruction of cutworms generally. It has been used with success against the variegated cutworm.

Bran	20 pounds.
Molasses	1 quart.
Paris green or white arsenic	½ pound.
Water	2 to 3 gallons.

Mix the bran and paris green thoroughly in a wash tub, while dry. Dissolve the molasses in the water and wet the bran and poison with the same, stirring well so as to dampen the bran thoroughly.

A simple formula for small areas is one quart of bran, one teaspoonful of paris green and one tablespoonful of molasses, with sufficient water to moisten the bran.

The mixture should be scattered thinly along the rows of plants as soon as cutworm injury is noted. This should be done after sundown so that the bait will be in the very best condition to attract the cutworms when they come out to feed at night.

Hand Picking.—Within small areas, as soon as injury is noticed the cutworms can as a rule be easily located in the soil, about an inch or so beneath the surface, and within a radius of a few inches of the plant, and destroyed by hand.

THE CABBAGE LOOPER, *Autographa brassicae* Riley

Injuries by this insect are fortunately of uncommon occurrence in Canada. In the Eastern Provinces the pest is occasionally destructive to such vegetable crops as cabbage, cauliflower, lettuce, pea, etc. In greenhouses, the caterpillar has occurred in sufficient numbers to cause important injury to cineraria, snapdragon, geranium, carnation, tomato, tobacco and lettuce.

Fig. 8.—Cabbage looper feeding on cucumber leaf (authors' illustration).

DESCRIPTION AND HABITS

The Larva or Caterpillar.—The full grown caterpillar is about an inch and a quarter in length, pale green in colour, with longitudinal whitish stripes. It

walks like the measuring worms or loopers, owing to the fact that it has only three pairs of prolegs at the end of the body. When mature it spins a gauzy silken cocoon on the leaves.

The Pupa.—The pupa is plainly visible through the thin silken cocoon. It is reddish-brown in colour and about three-quarters of an inch in length. Specimens which changed to pupæ on January 27, produced moths on February 23.

The Moth.—The moth is dark in colour, the upper wings being almost black or very dark grey, marked with small white points and indistinct bands, and having a silvery U-shaped spot on the middle of each front wing and a smaller round silvery dot close to it on the outside.

CONTROL

In the outbreaks of the cabbage looper in Canada, hand picking of the caterpillars proved to be a satisfactory remedy. In the event of this insect becoming more destructive in Canada, doubtless, serious losses in greenhouses would take place. In the report of the Dominion Entomologist for 1900, the following statement is made: "The most practical means of preventing the work of the caterpillars on lettuce in forcing houses is stated to be the keeping of the ventilators closed with mosquito netting. It is thought that the eggs are sometimes laid on plants before they are taken into the houses, but probably the moths gain access to forcing houses more generally through the ventilators."

If the looper is present in large numbers, it may be controlled on ornamentals by spraying or dusting with an arsenical (see page 6) and on vegetables by using a dust or spray of pyrethrum (see page 7). However, experience indicates that ordinarily under glass the insect may be readily controlled by hand picking.

THE YELLOW WOOLLY-BEAR, *Diacrisia virginica* Fabr.

Occasionally this well-known woolly-bear caterpillar is found in destructive numbers in greenhouses in autumn. It is, however, a garden species feeding on a great variety of plants, such as dahlia, sunflower, corn, cabbage, clover, etc.

DESCRIPTION AND HABITS

The Larva or Caterpillar.—This is the only form of the insect ordinarily found in greenhouses. When mature the caterpillar is about one and a half inches in length, and as the name "woolly-bear" would indicate it is clothed with dense clusters of stiff hairs, not always of a yellowish colour, however, as in many specimens they are of a dark rusty or reddish-brown colour, or even nearly white. The body colour also varies, and in the paler specimens a more or less broken lateral blackish stripe, as well as bands of the same colour across the back between each of the segments, may be seen.

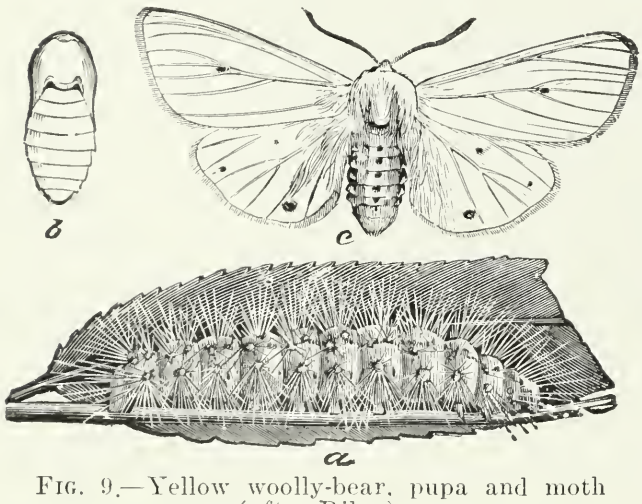


Fig. 9.—Yellow woolly-bear, pupa and moth (after Riley).

The injuries to plants in greenhouses upon which these caterpillars have been found feeding in Canada, relate particularly to chrysanthemums and marigolds. The caterpillars had undoubtedly migrated to the greenhouses from nearby gardens. When such happens injury is likely to take place to almost any succulent plant reached by the larvæ. As mentioned above, they

are very general feeders and in addition to low-growing plants, they are also found on the foliage of bushes and even trees. They are active feeders and if present in numbers cause very noticeable injuries by eating the leaves.

When full grown, in autumn, the caterpillar spins a cocoon and passes the winter as a pupa inside this coarse silken cover. In May and June of the following year the moths appear.

The Moth.—Both sexes of the moth are similar in appearance, the wings being snowy white, marked with a few black dots. A row of black spots is present down the centre of the abdomen and another on either side; between these there is a longitudinal orange stripe. With the wings spread, the moths vary from $1\frac{1}{2}$ to $1\frac{3}{4}$ inches in width.

CONTROL

Hand Picking.—The simple remedy of hand picking will answer in most cases. The larvæ are conspicuous and should soon be noticed when the grower is working among his plants.

THE CORN EAR WORM, *Heliothis obsoleta* Fabr.

This well-known pest of sweet corn has on occasions caused important injury to the fruit of the tomato in greenhouses in Canada, particularly in the Province of Ontario. In October, 1921, there was an exceptional outbreak of this insect; up to that time the only other case on record of the caterpillar occurring in a greenhouse referred to a single specimen found at Ottawa, on October 28, 1898, feeding on pelargonium. Other flowering plants damaged in greenhouses in Ontario are chrysanthemum, primula, carnation and geranium. In 1932, in southern sections of Ontario, as for instance the Leamington district, large numbers of larvæ were present in greenhouses where tomatoes were being grown. Considerable injury was caused, particularly to the green fruit. The injury in gardens is largely confined to the ears of sweet corn, but tomatoes also are occasionally attacked.

Fig. 10.—Greenhouse tomato destroyed by corn ear worm (original).

The injury to the fruit of tomato referred to above is shown at fig. 10. It will be seen that the inside of the fruit is freely devoured by the caterpillars.

DESCRIPTION AND HABITS

The Larva or Caterpillar.—The caterpillar, when mature, "is from one and one-quarter to one and one-half inches in length. It varies in colour from a light green to dark brown, with rather indistinct stripes on the back and a wider, conspicuous, pale-coloured band along the side. The head is of a yellowish-brown colour."[1]

The Moth.—The front wings vary in colour from a light yellowish-brown to a darker brown, with rather indistinct lines and bands particularly near the outer margins. The hind wings are yellowish-brown, each with a wide dark brown marginal band. With the wings spread the moth varies in width from $1\frac{3}{8}$ to $1\frac{5}{8}$ inches.

[1] Cir. No. 14, Ent. Br., Dom. Dept. Agriculture.

CONTROL

Hand Picking.—Should this caterpillar be found in greenhouses, the probability is that hand picking will be a satisfactory remedy. Larvæ thus collected may be destroyed by dropping them in a pail or other vessel containing water on the top of which is a film of coal oil. Screening the doors and ventilators will exclude the moths.

THE CHRYSANTHEMUM LEAF-MINER, *Phytomyza chrysanthemi* Kowarz.

This insect, which is also known as the marguerite fly, has a wide distribution and has been a pest of considerable importance in Canada in the Provinces of Quebec, Ontario and British Columbia.

DESCRIPTION AND HABITS

The Egg.—The egg is very small and according to Smulyan[1] varies in size from ·25 to ·33 mm. in length by ·14 to ·17 mm. in width. It is smooth, of an elongate-oval shape and, in general, colourless. In March, 1911, infested foliage was received at Ottawa from Vancouver, B.C., and a female fly was observed to oviposit.

An unpublished note made by the late Dr. C. Gordon Hewitt reads as follows: "Single egg is deposited near midrib. A hole is bored by means of the ovipositor, which is pushed in, the distal portion of the abdomen being at right angles to the surface of the leaf. The ovipositor worked by a screwing motion of the abdomen then scoops out a circular space in the sub-epidermal tissue of the leaf in which the egg is deposited. The fly then moves back and applies the proboscis, for what purpose I could not see, rapidly several times to the puncture. The whole process takes less than one minute." The latter action was doubtless for the purpose of feeding. A single female may lay from 125 to 150 eggs. The length of the egg stage under normal greenhouse conditions is about five days.

Fig. 11.—Chrysanthemum leaf showing work of chrysanthemum leaf-miner (authors' illustration).

The Larva or Maggot.—The young maggot on hatching from the egg, at once begins to feed upon the tissues immediately below the epidermis of the upper surface. The larva, which is colourless, as it develops makes conspicuous mines, irregular in shape and size, in the leaves as indicated in fig. 11. This injury has a decided weakening effect upon the plants, affecting their whole growth, which is frequently seen in the small size of the flowers produced. Badly infested leaves after drying remain attached to the plants and where the infestation is serious the smaller plants particularly may be killed outright. When full grown in about two weeks or so, the maggot is 3·5 mm. in length; it changes to the puparium stage within the mine and after a further period of about two weeks the adult fly emerges.

[1] Bull. 157, Mass. Agr. Exp. Station.

The Fly.—The adult fly is a small, two-winged insect, about one-twelfth of an inch in length, the front portion of the body being greyish in colour, the posterior portion blackish. In habit, as has been stated by Smulyan, the flies "crawl lazily about, or make their way from leaf to leaf and from plant to plant in a skipping or hopping flight, very seldom flying more than a few feet at a time." The same author states that "the females, at least, feed during their adult life, the food being the juices of the leaves of the host plants. To this end the epidermis of the leaf is pierced and the parenchyma in contact with it at that point is cut or macerated by means of the tubular ovipositor." In 1914, opportunity was provided for examining a large number of punctures made by the females and it was observed that all those on the upper surface and a majority of those on the lower had been made for feeding purposes. Thirty-three punctures on the upper surface were examined and in only one of these was an egg found; on the lower surface eight eggs were found in eighteen punctures examined. This feeding injury results in the formation in the leaves of wart-like growths.

Food Plants.—Marguerite is the favourite food plant of the insect in Canada. One grower in the Montreal district found the insect, in addition to marguerite, working in the foliage of bridal rose, chrysanthemum, gazania and German ivy. The larva is also known to attack feverfew, helianthus, goldenrod, ragweed, dandelion, ox-eye daisy and other plants.

CONTROL

Nicotine Sulphate.—The spraying of the infested plants with nicotine sulphate 40 per cent strength, has been found to be a satisfactory remedy for this insect. In the strength of one part of the nicotine sulphate solution to 400 parts of water, several investigators found this killed the eggs and larvæ and that a stronger mixture, namely, one part in 200 parts of water, destroyed the pupæ. In greenhouses in Canada where the nicotine sulphate 40 per cent has been used, control has been secured.

Spraying should begin as soon as injury is detected, and further applications, as necessary, made about a week or ten days apart. The undersides of the leaves should be sprayed as well as the uppersides.

Summer Oil Spray.—Out-of-doors, W. Downes, Dominion Entomological Laboratory, Victoria, B.C., has controlled infestations on marguerites by using a 2 per cent summer oil spray with $1\frac{1}{2}$ teaspoons of nicotine sulphate (40 per cent) to each gallon of spray; two applications, a week apart.

THE VIOLET SAWFLY, *Allantus canadensis* Kby.

In 1898, as reported by Fletcher in his annual report as Dominion Entomologist[1], the larva of this insect caused considerable injury to the foliage of violet plants in a large Toronto greenhouse. The outbreak was investigated by the senior author and a second visit to the same greenhouse was made in November, 1899. This, apparently, is the only record of this insect as a greenhouse pest in Canada. In the United States, there are several records of the insect being destructive in greenhouses.

DESCRIPTION AND HABITS

The Egg.—According to Chittenden[2], the egg is small, whitish, soft and delicate. The eggs are laid singly, although a number may be present on the same leaf.

[1] Rep. Ent. and Bot., Dom. Exp. Farms, 1898.
[2] Bull. 27, U.S. Bur. Ent.

The Larva.—The larva at first is slightly less than one-eighth of an inch in length and in colour light slate. It soon begins to feed on the leaf "cutting out little holes from the lower surface and later when more mature, eating along the edge of the leaf." When full grown the larva is about one-half of an inch in length, smooth and in colour bluish-black. In its later stages it is capable of causing serious injury to the plants.

The Pupa.—The pupa measures about 7·5 mm. in length and is nearly white in colour, the eyes turning darker as it approaches the time for final transformation. The change to pupa in the confinement of our rearing jars took place in the pith of sunflower stems placed there for the purpose. (Chittenden).

The Adult.—The adult sawfly with its wings spread is about one-half an inch in width; in length it is about five-sixteenths of an inch; the body is black. It has been collected outside in the Ottawa district in May and June.

Food Plants.—In the greenhouse, the only injury recorded is to violet. In the Ottawa district the larvæ have been found out-of-doors, feeding on garden pansies and violets. In years of abundance they have caused a good deal of harm, oftentimes completely destroying plants, in late June and the first half of July.

CONTROL

The sawfly may be controlled by applying a lead arsenate dust (see page 6).

FULLER'S ROSE BEETLE, *Pantomorus godmani* Cr.

There are few records of this beetle causing injury in greenhouses in Canada. In 1889, a serious infestation was investigated in an Ottawa greenhouse and this is referred to in the Report of the Dominion Entomologist for that year. It was noted that a number of different plants had been eaten by the beetles, as well as the roots of certain plants by the grubs. The beetle is nocturnal in habit, hiding in the daytime beneath leaves, etc. Injury, therefore, is effected chiefly during the night. The insect is unable to fly.

DESCRIPTION AND HABITS

The Egg.—Chittenden[1] states that "an individual egg measures about ·9 mm. in length and about one-quarter that in width. It is smooth, soft, and of a pale translucent yellow. The normal form is ellipsoidal, but great variability occurs from the close compression of the eggs, as they are deposited in rows." The egg stage lasts about a month. On hatching the young grub at once enters the soil in search of food.

Fletcher in the report referred to above describes the larva and beetle as follows:—

"*The Larva.*—A thick white legless grub, when full grown one-fourth of an inch in length, the body curved, wrinkled above and flattened below, covered with short tawny bristles. Head yellow with dark, black-tipped, sharp mandibles, with which it consumes the young rootlets of various greenhouse plants."

"*The Beetle.*—The perfect beetle is a brown weevil a little more than one-fourth of an inch in length, with a short thick snout, and long slender antennæ or feelers, bent abruptly in the middle. The wing cases are indistinctly striate, and bear rows of large punctures and minute hairs. A whitish stripe runs along the sides of the thorax and half way down the sides where it terminates as an oblique white dash, reaching to the middle of each wing-case."

The grub and beetle are similar in appearance to the grub and adult of the Black Vine Weevil (*See* fig. 31).

[1] Bull. 27, U.S. Bureau of Ent.

Food Plants.—In the Ottawa greenhouse the foliage of roses and lilies was specially attacked by the beetles and the roots of roses and begonias by the grubs. In other greenhouses in Canada the insect has attacked abutilon and plumbago. In the United States there are records of the insect feeding upon a number of other greenhouse plants.

CONTROL

The only control measures suggested at the present time are: Hand picking the adults; keeping the foliage lightly covered with lead arsenate dust (see page 6) and mulching the soil with tobacco dust.

THE AZALEA LEAF-MINER, *Gracillaria azaleella* **Brants.**

This species has been found on azaleas imported from Europe, particularly Belgium. In the United States, it has become established as a greenhouse pest undoubtedly having been introduced from Belgium and Holland. It has also been found on stock from Japan. There is no record of the insect breeding in any greenhouse in Canada but as it has become established in the United States, for instance in the states of New Jersey and New York, it may at any time become a pest of importance in Canadian greenhouses.

Fig. 12.—Leaves showing work of azalea leaf-miner (original).

DESCRIPTION AND HABITS

The Larva or Caterpillar.—Felt[1] states that "the small, yellowish caterpillars, when nearly full grown, about one-fourth of an inch long, usually turn over the tip of an azalea leaf, webbing it down with fine silken strands and eating away the tissues of the infolding underside. The injured portion turns dry and the retreat contains numerous small black particles of frass."

The Moth.—"The parent insect is a delicate moth with a wing spread of only three-eighths of an inch. The forewings are yellowish, with large purplish areas and a series of purplish dots along the costal margin of the broad yellowish portion. The hind wings are slender, light pearly-grey and long-fringed."

CONTROL

In the state of New Jersey, Weiss[2] states that in private greenhouses it is usually controlled by the removal of infested leaves by hand. In one large commercial establishment, the same author records that the spraying of infested plants with arsenate of lead paste in the strength of eight pounds to 100 gallons of water gave good results. In New York state, Felt records that treatment with tobacco preparations either by fumigation or spraying appeared to be a very effective method of control. Such treatment, however, should not be practised while the plants are in bloom, otherwise injury would probably occur.

[1] 29th Rep. State Ent., N.Y., 1913.
[2] Ent. News, XXIX, 114.

THE DIAMOND-BACK MOTH, *Plutella maculipennis* Curt.

This well-known pest of cabbage, cauliflower and certain other vegetable plants has occasionally been found attacking flowering plants grown in greenhouses, as for instance stocks. The insect has a wide distribution being present in all provinces of Canada.

DESCRIPTION AND HABITS

The Larva or Caterpillar.—The mature caterpillar which feeds upon the foliage of plants is about three-eighths of an inch in length when full grown. It is light green in colour, very active, and when disturbed wriggles backwards. When it has completed its growth, it spins an open network cocoon on the lower sides of the leaves and then changes to the pupal state.

Fig. 13.—Work of the caterpillars of the diamond-back moth; cocoon on leaf (after Gibson).

The Moth.—The moth is about one-quarter of an inch in length, slender in appearance, and in general colour, greyish or brownish. When at rest the wings are folded against the sides of the body.

CONTROL

Experiments conducted in Nova Scotia by Arthur Kelsall, lately in charge of insecticide investigations, indicated that satisfactory control of the insect may be obtained with pyrethrum and derris dusts. Similar results have been secured in the United States.

A pyrethrum spray, using 1 ounce of fresh pyrethrum insect powder to 1 gallon of water, applied with pressure, has also been recommended.

THE STRAWBERRY ROOT WORM, *Paria canella* Fab.

This insect is common in strawberry and raspberry plantations in Ontario and other sections in Eastern Canada. For several years it has been a serious pest of roses grown under glass in the United States, but, so far, in Canada it has been reported from only one greenhouse at Brampton, Ontario, where it was present in moderate numbers. It should be watched for and if found control measures should be promptly applied.

DESCRIPTION AND HABITS

The Egg.—The eggs are white and are usually laid in masses of from 4 to 15 in dried up or dead leaves. They hatch in from 7 to 15 days.

The Larva or Grub.—The larva when full-grown is about one-fifth of an inch long and in general appearance resembles a small white grub. It spends its entire life in the soil feeding on the young rootlets, and changes to a beetle within an earthern cell. From egg to adult requires from 50 to 70 days.

The Beetle.—The beetle is oval in shape and in length about an eighth of an inch. It varies in colour, some individuals being black, others yellowish or

brown. Two or more generations a year may occur under glass, the beetles being most numerous during the summer months. Those appearing in the fall remain over winter in the mulch or soil, but occasionally may feed on sunny days.

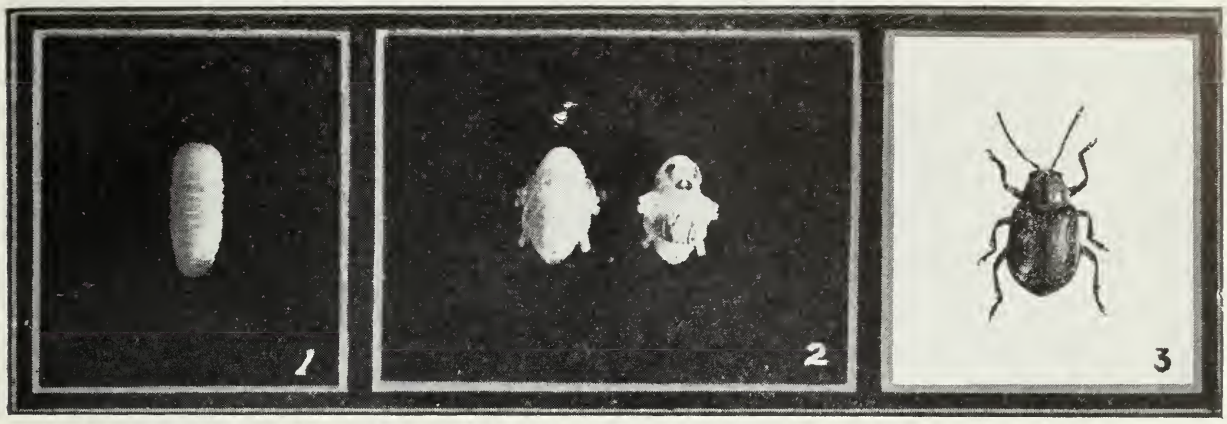


Fig. 14.—The strawberry root worm; 1, larva; 2, pupæ; 3, adult beetle; all enlarged four times (authors' illustration).

Food Plants.—The only plant known to be attacked under glass is the rose. The beetles eat out small areas of the foliage, giving it a shot-hole appearance, but the most severe losses are caused by feeding on the new eyes and young shoots, especially just after the resting period. The grubs weaken the plants by feeding on the rootlets and girdling the more mature roots.

CONTROL

Roses being attacked by the beetles should be kept covered with a light coating of 85-15 sulphur-lead arsenate dust, and in March the soil should be mulched with a quarter-inch layer of tobacco dust, containing not less than one per cent nicotine. This mulch should be maintained throughout the summer by adding more dust.

Fig. 15.—Strawberry leaves destroyed by strawberry root worm (authors' illustration).

In order to avoid infestations of strawberry root worm, strawberries and raspberries should not be grown in the immediate vicinity of rose houses.

97773—5½

CARR'S WATER-CRESS LEAF-BEETLE, *Phaedon carri* Hatch.

In October and November, 1938, the chrysomelid beetle, *Phaedon carri* Hatch, was found causing important injury to water-cress grown in a greenhouse near Ottawa. Like other chrysomelids, the grubs and adult beetles devour portions of the leaves.

This is the only case on record of this insect feeding upon a cultivated crop. It was described under the above specific name in 1928 from material collected in the Province of Alberta and the State of New York. Material in the Canadian National Collection from Alberta, Manitoba, Ontario, and Quebec, indicates that the insect is apparently widely distributed in Canada.

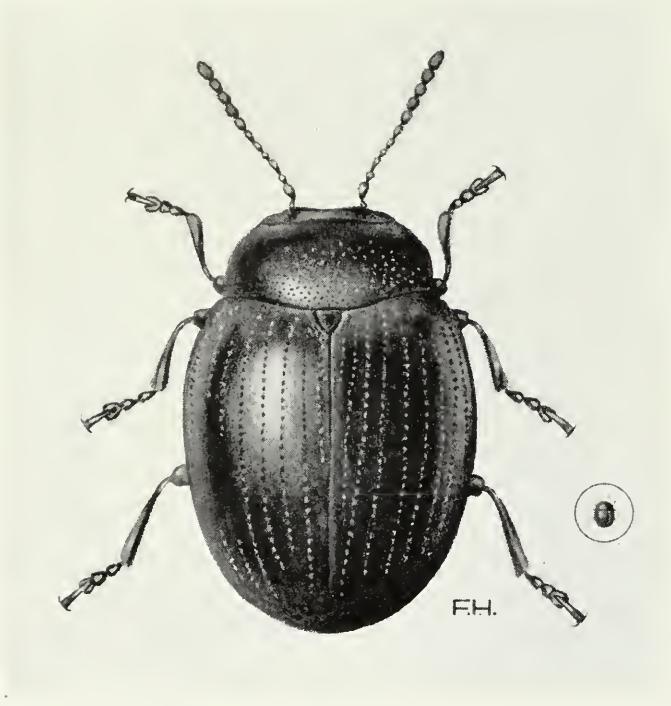


Fig. 16.—Carr's water-cress leaf-beetle; enlarged and natural size (original).

DESCRIPTION AND HABITS

The beetle is about one-eighth of an inch in length, the wing-covers and upper portions being of a shining copper-like colour, the body underneath shining black.

No opportunity to study the biology of the species has presented itself. Other species of the genus lay eggs singly on the leaf, slightly embedded in the epidermis or midrib. From these the grubs emerge in due course. These latter may be found on the foliage, feeding actively with the adults.

CONTROL

A. G. Dustan of the Division of Entomology investigated the above outbreak and used two different dusts, namely (1) 1 oz. fresh pyrethrum insect powder mixed with 1 oz. of talc and (2) 1 oz. of derris dust with 1 oz. of talc. In the plots where the latter mixture was used, perfect control was obtained.

THE CLEAR-WINGED GRASSHOPPER, *Camnula pellucida* Scudd.

Grasshoppers are not considered as greenhouse pests. During 1921, however, the above species caused considerable injury to an important lettuce crop in a large greenhouse in the Province of Alberta. The outbreak was investigated by H. L. Seamans, in charge of the Dominion Entomological Laboratory, at Lethbridge, Alta.

According to report, the owner of the greenhouse introduced a large quantity of soil into his houses in early spring. The neighbourhood had been devastated by the clear-winged grasshopper and large numbers of eggs of the species had been deposited in the soil used. The eggs hatched in the greenhouse in the first half of April and the young hoppers at once attacked the lettuce plants riddling the leaves to such an extent as to render the plants unsaleable.

CONTROL

Prompt applications of the well-known poisoned bran mixture (page 22) soon controlled the infestation.

THE GREENHOUSE CAMEL CRICKET, *Tachycines asynamorus* Adelung.

The insects known as camel crickets are found in cool, damp situations. They are frequently complained of in cellars of houses having earth floors. An interesting infestation in a greenhouse at Winnipeg, Man., of the above species was reported in 1932, by Prof. A. V. Mitchener, of the Manitoba Agricultural College. Various varieties of greenhouse plants were destroyed. A few individuals were also found in a greenhouse at Ottawa. The species apparently is widespread in distribution. Earlier records relate occurrences in greenhouses in several localities in the United States. The indication is that the species was introduced into the United States from Japan.

Fig. 17.—The greenhouse camel cricket; slightly enlarged (original).

DESCRIPTION AND HABITS

Camel crickets are curiously shaped insects, with their long legs, long feelers, and no wings. Otherwise they are much like the true crickets. They are usually of a pale brown colour. The species here discussed has a body length of about one-half inch, and is banded with darker brown. The ovipositor of the female is one-half inch long. In the male, there is a pair of slender processes at the end of the body.

CONTROL

For the above outbreak, the poisoned bait as used for cutworms was recommended, (see p. 22). The mixture was scattered where the crickets would find it. Two applications were made, the second five days after the first. Prof. Mitchener reported later that complete control had been secured.

THE CURLED ROSE WORM, *Allantus cinctus* Linn.

This insect, which is known to attack the foliage of roses grown out-of-doors, has occasionally caused damage to roses grown in greenhouses in Eastern Canada. In the Province of New Brunswick, R. P. Gorham, Dominion Entomological Laboratory, Fredericton, N.B., has observed infestations in several years.[1]

DESCRIPTION AND HABITS

In the greenhouse, according to Gorham, the adult insects appear early in March and continue to appear during April and early May. Females in laying eggs were observed to cut incisions "1·5 mm. long in the tough upper epidermis of the leaf." The incubation period ranged from 8 to 12 days. "Adults, eggs, larvæ in all stages, including the pre-pupal, can be found in the latter part of April."

[1] Rep. Ent. Soc. Ont. 1927:70.

The larva, (fig. 18) feeds on the foliage much the same as other sawfly larvæ. In describing the feeding habit, Gorham states: "The young larvæ feed at first on the underside of the leaf, biting out pieces of the parenchyma but not breaking the upper epidermis, which remains at first as a transparent, and later as a brown spot. The exit scars and first larval feeding scars disfigure the upper surface of the plant and are particularly objectionable to the florist when he desires to cut sprays of bloom with good foliage. The second, third, and fourth instar larvæ feed on the leaf margins from beneath, cutting out larger amounts of tissue but leaving clean edges and less noticeable disfigurement of the foliage.

FIG. 18.—Work of the curled rose worm; larva on leaf (after Gibson).

"When full grown, the larva burrows in the pith of a rose branch, forming a small chamber closed at both ends with thin partitions of pith fragments. Sometimes two or more larvæ enter the same branch and occupy chambers separated from one another by these thin partitions or plugs. Several months are passed within these chambers as larvæ, the change to the pupal form taking place some two weeks before the emergence of the adults."

The adult is a rather small, four-winged, wasp-like insect with a black body about two-fifths of an inch in length; the body of the female has a whitish band on the abdomen. All the wings are transparent.

"Two generations develop each year; one attacking the plants in March, April and May, the second in September, October and November."

CONTROL

Fumigation with hydrocyanic acid gas will destroy the adults. In New Brunswick, Gorham states: "Greenhouse experience has shown that the larvæ are readily killed by spraying the undersides of the foliage with an arsenical spray. The stain left on the foliage by the drying sprays, however, is objectionable to the florists. Trial, therefore, was made of dusting the leaves with ground derris dust during different larval instars. It was found that like other sawfly larvæ, these were very susceptible to the toxic action of this material, and that they dropped in a helpless condition within two hours after application. No objectionable stains were left on the foliage or blooms."

SPRINGTAILS *(Collembola)*

Few records are available of serious damage by these insects to greenhouse plants. Lochhead[1] records injury to primrose seedlings at Guelph, Ont., apparently by an unidentified species. The common garden springtail, *Bourletiella hortensis* Fitch, is known to cause injury to plants grown under glass, and, in Ontario, the species *Folsomia fimetaria* L. is often found in cultivated soil and commonly reported from earth in flower pots. The species causes damage to plants by gnawing the fine rootlets. In British Columbia, *Onychiurus armatus* Tullb. has been found in greenhouses, occurring in soil and among potted plants. It is present, also, in other provinces. *Proisotoma minuta* (Tullb.) was found in a greenhouse in Winnipeg, Man., on bulbous iris; *Isotomurus palustris* (Mull.) and *Pseudosinella violenta* Fols. are also known to occur in greenhouses.

Folsom[2] lists other species which have been reported as being destructive to greenhouse plants. Of these the following have been recorded from Ontario by James[3]: *Xenylla humicola* (Fab.) Tullb.; *Achorutes macgillivrayi* Fols.; and *Lepidocyrtus cyaneus* Tullb.

The mushroom springtail, *Achorutes armatus* Nic., is widespread in distribution, and a major pest of mushrooms. C. A. Thomas[4] states that when "abundant in the beds before casing, they eat through the strands of mycelium and sometimes will entirely destroy it . . . Because of their very small size and dark colour, springtails are usually not noticed after they have entered the beds, and the grower may ascribe the disappearance of the mycelium to some other cause."

From several localities in Canada springtails have been reported as occurring in large numbers in mushroom houses, infesting the beds and thought to be damaging the mycelium. The species mentioned above has been identified in this connection. *Xenylla humicola* (Fab.) Tullb., has also caused damage to cultivated mushrooms in Canada.

DESCRIPTION AND HABITS

In size these insects are about one twenty-fifth of an inch in length and in colour may be dull-black, green or yellowish. They occur commonly in soil containing leaf mould or other decaying vegetation. The common name of "springtails" has been given to these insects from the fact that most of the species have a springing organ on the underside of the body which enables them to spring or leap into the air.

CONTROL

In Mushroom Houses.—In a circular prepared by R. H. Painter, of the Division of Entomology, the following appears:—

"These pests can be controlled to a large extent by careful preparation of the manure. The outside of the piles should always be turned into the centre at each turning and the manure should heat to 150° F. at which temperature these insects are killed. If the manure in the beds heats to 150° F. when first placed in the house large numbers will also be destroyed.

Springtails are often found in heaps in the houses; such should be swept up and burned. Large numbers may be destroyed by means of light traps. A shallow pan filled with kerosene is placed on the bed or in the aisle and an electric light or lantern suspended a few inches above the pan. The springtails are attracted to the light and are killed by the oil. Sticky fly paper may be used but requires more attention.

---

[1] Rep. Ent. Soc. Ont., 1904.
[2] Jour. Econ. Ent. 26, 936, 1933.
[3] Trans. Roy. Can. Inst. XIX, 77-116, 1933.
[4] Bull. 270, Penn. Exp. Stn., 1931.

A 3 per cent nicotine-lime dust, (see page 7) is effective when dusted lightly over the beds and in quantity in the aisles where the springtails are abundant. In severe infestations fumigation with paradichlorobenzine has given control. This material (crystals) should be broadcast over the beds, 1½ pounds to each 400 square feet of bed space. The beds should then be covered with several layers of newspaper and the house closed for 48 hours. A thorough airing should follow this treatment as the fumes may taint the mushrooms. All mushrooms should be picked before fumigation starts, as the fumes have a burning effect."

In Greenhouses.—A nicotine dust similar to that used in mushroom houses should be of value in greenhouses. It has been reported that *Onychiurus armatus* Tullb. was controlled by submerging potted plants in nicotine sulphate (40%) 1 – 800, for 15 minutes.

ANTS

Complaints are occasionally received of the presence of ants in greenhouses. They cause annoyance by invading the houses particularly those infested with aphids, for the reason that they are very fond of the honey-dew emitted by the aphids. One of the most common and troublesome species is the small red ant, or Pharaoh's ant, *Monomorium pharaonis* L. (fig. 19).

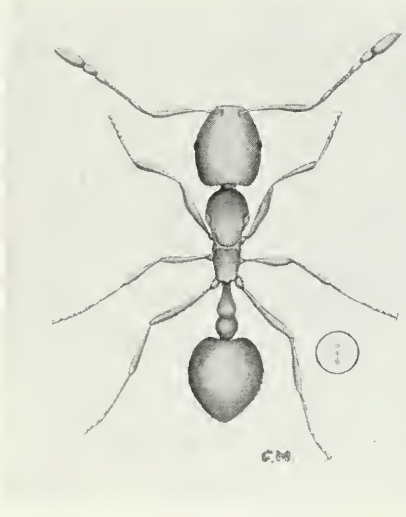


Fig. 19.—Pharaoh's ant; enlarged and natural size (after Gibson and Twinn).

CONTROL

Scatter sodium fluoride lightly in places frequented by the ants, leaving the powder undisturbed until the insects have disappeared. As sodium fluoride is poisonous, care should be taken to prevent children or domestic animals from gaining access to it. A bait trap which has been used with success against Pharaoh's ant may be made by taking a small tin can with a tight lid, puncturing several holes in the sides, and introducing a piece of sponge soaked in a syrup prepared by mixing 8 ounces of sugar, ½ ounce of honey and adding 30 grains of sodium arsenate or 15 grains of sodium arsenite in 1 pint of hot water. The worker ants are greatly attracted to the bait and take it to their nests, to feed the larvæ and queens. Thus the whole colony is destroyed.

TERMITES

These insects, also known as "white ants," are not as yet pests of importance in Canada. In the United States, however, migrations into greenhouses from outdoor colonies are known to occur particularly of the species known as *Reticulitermes flavipes* Koll. The food of termites is composed entirely of cellulose, which they obtain principally from dead or decaying wood. Their natural habitat is in the forest, but with the removal of forest growth in infested regions, they have become increasingly destructive to the woodwork and contents of buildings. In the United States and other countries where they are pests, control and prevention of damage is attempted by various methods such as locating and destroying the colonies, treating wood with chemical preservatives, improved building construction, etc.

FIG. 20.—Termites, *Reticulitermes flavipes* Koll.; winged adults above, mature workers below; about four times natural size (after Gibson and Twinn).

SUCKING INSECTS

THE GREENHOUSE WHITEFLY *Trialeurodes vaporariorum* West.

The greenhouse whitefly has very general feeding habits and attacks a great variety of plants. Among its preferred food plants are the following: tomato, cucumber, lettuce, pelargonium, salvia, ageratum, lantana, heliotrope, fuchsia, hibiscus, abutilon, solanum, cigar plant, primula and schizanthus.

DESCRIPTION AND HABITS

The Egg.—The females deposit their eggs on the undersides of tender leaves. The egg is very small, irregularly ovoid and in colour is light green or yellowish-green, becoming darker before hatching. It is attached to the leaf by a short stalk. The eggs hatch on an average in about 12 days. Under laboratory conditions, the incubation period of eggs kept under observation varied from 12 to 17 days, the average being about as stated. The number of eggs laid by individual females in these experiments varied from 16 to 158, the average being 88.

The Larva or Nymph.—The nymph is flat in shape, oval in outline, and

FIG. 21.—Greenhouse whitefly; adults and nymphs; enlarged four times (authors' illustration).

pale greenish in colour. The newly hatched young move about for a short time and then insert their beaks into the leaves and become stationary. They are sucking insects feeding greedily on the plant juices and in about four weeks time, after passing through four stages, transform to adults. The last stage nymphs are armed with white waxen filaments which radiate from the body. The duration of the nymphal life in experiments with 52 nymphs varied from 21 to 42 days, the average being 29 days.

The Adult.—The perfect insect is a small four-winged moth-like creature about one-sixteenth of an inch long, the wings being pure white in colour and the body yellowish. Like the nymphs they feed on the undersides of the leaves. The length of life of six females kept in confinement varied from 18 to 68 days, the average being 40 days, the period of egg-laying ranged from 7 to 58 days, the average being 33 days. Severely attacked leaves dry up and die. Infested plants become covered with a sticky liquid which is excreted by the insects and in which very frequently a sooty fungus develops.

CONTROL

Fumigation.—Fumigation with hydrocyanic acid gas (described on page 7) is the remedy commonly adopted by florists. The strength of the cyanide necessary will depend upon the tightness of the house. For tight greenhouses the initial dose should be one-eighth of an ounce of calcium cyanide for each 1,000 cubic feet of space.

Soap Solutions.—Whale oil soap is useful for destroying the whitefly and should be used in the strength of one and a half ounces to one gallon of water. The spray kills by contact and should, therefore, be directed to reach the undersides of the leaves where the insects are clustered, as only those which are actually hit by the spray will be killed. The unpleasant odour of whale oil soap is objectionable to many lovers of ornamental plants. In the case of house plants thoroughly spray the undersides of the foliage with linseed oil soap 1-200, or with a pyrethrum extract (see page 7). Several applications of spray may be necessary.

Parasites.—During recent years, the Dominion Parasite Laboratory at Belleville, Ont., has distributed to owners of greenhouses in the various provinces, thousands of specimens of the parasite, *Encarsia formosa* Gahan, for liberation in houses infested with the greenhouse whitefly. The results have been most satisfactory. In applying for the parasite, the following information should be given: greenhouse area (square feet), crops infested and stage of development, area infested, degree of infestation (light, medium or heavy), and night temperature.

SCALE INSECTS

Among the sucking insects which commonly infest greenhouse plants are several species of scale insects. They are found on various kinds of house plants, more frequently, however, on such plants as ferns, palms, oleanders, etc. Ferns taken in as "boarders" are almost invariably infested with scale insects.

The following are well-known greenhouse species:—

The Soft Scale, *Coccus hesperidum* Linn. This is a soft, oval, slightly convex, brownish species, about one-eighth of an inch in length; it occurs on such plants as oleanders, citrus plants, bay trees, etc. It is one of the larger of the scale insects found in greenhouses.

The Hemispherical Scale. *Saissetia hemisphærica* Targ., is also a large brown species and in general is similar to the soft scale, hemispherical in shape and frequently a pest of ferns, crotons, palms and orchids.

Plate III

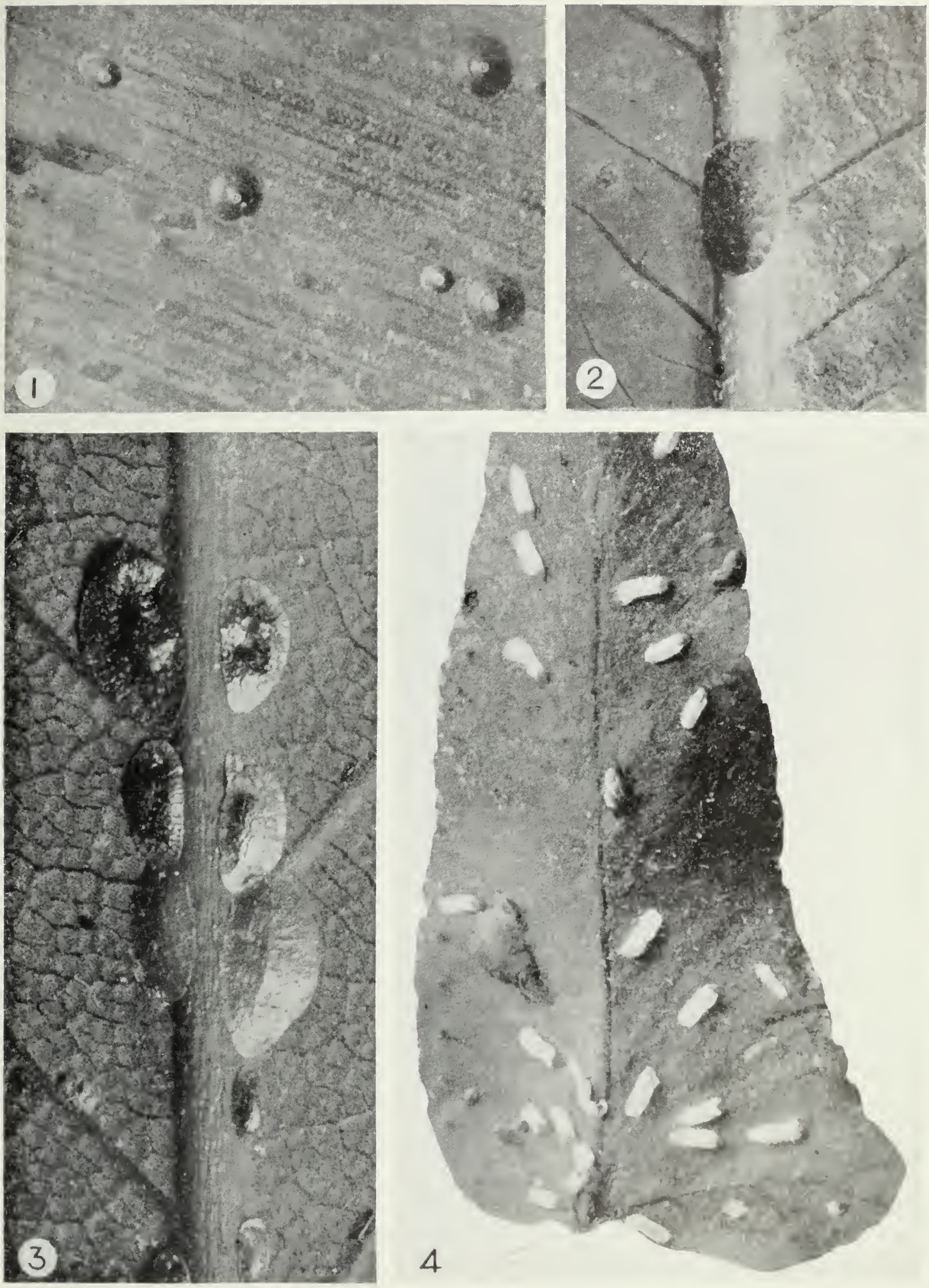


Fig. 1.—Florida red scale on palm leaf; 2, hemispherical scale on croton: 3, soft scale; 4, fern scale, males, females and young; all figures much enlarged (original).

97773—6½

PLATE IV

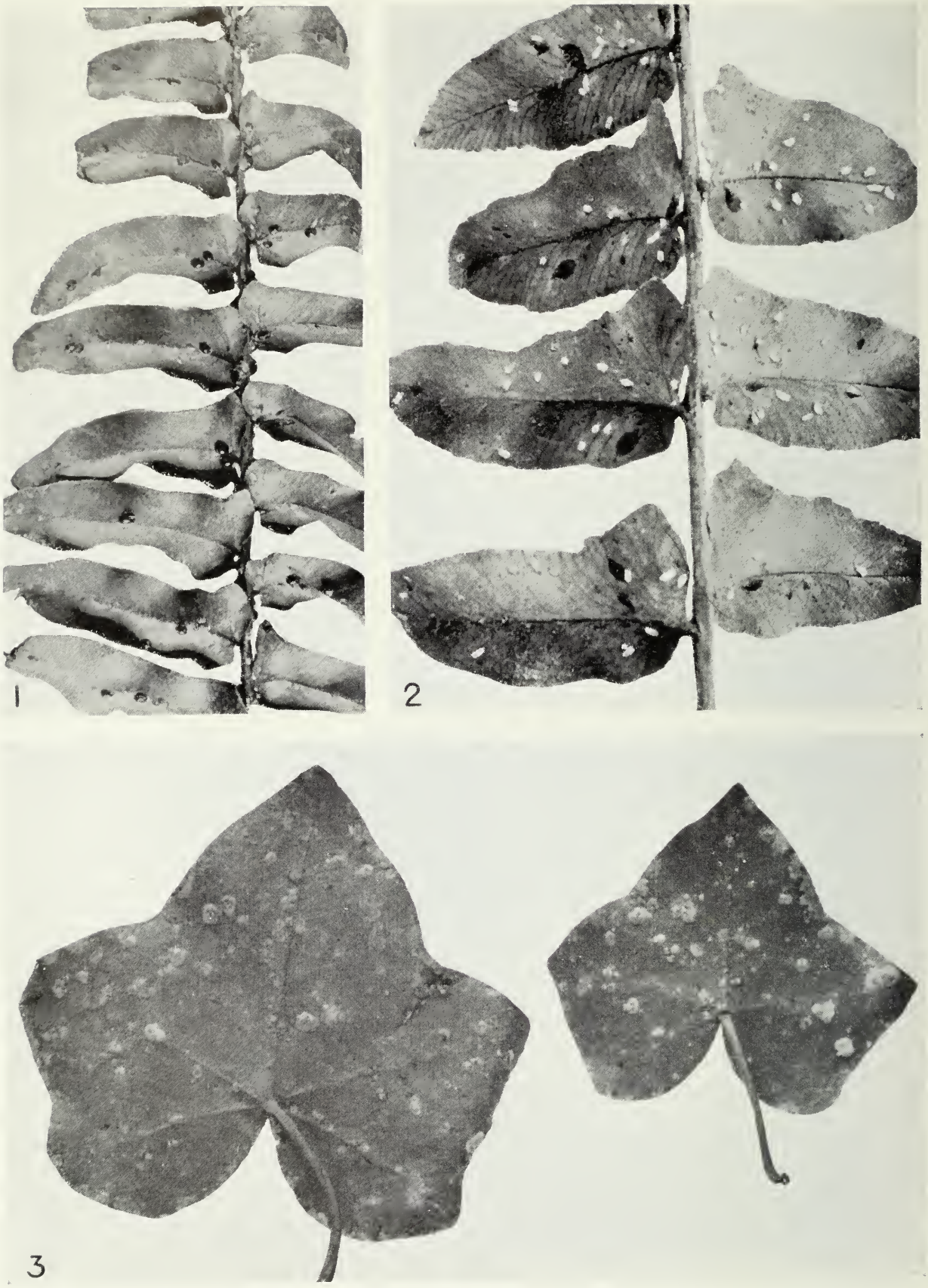


FIG. 1.—Common mealybug; 2, long-tailed mealybug; 3, coconut mealybug on Kentia; (original).

The Oleander Scale, *Aspidiotus hederæ* Vall., is a common greenhouse species. It is circular, nearly flat, about one-sixteenth of an inch in diameter and in colour is whitish or light grey. It infests palms, oleanders, crotons, dracena, acacia, ivy, etc.

The Florida Red Scale, *Chrysomphalus aonidum* Linn., is frequently abundant on palms, rubber plants, oleander, etc. It is about one-sixteenth of an inch in diameter, circular and slightly convex in shape; dark purplish-brown in colour with a nearly central nipple-like prominence.

The Fern Scale, *Hemichionaspis aspidistræ* Sign., or as it is erroneously called "the stationary white fly" commonly infests Boston ferns and allied varieties, and *Pteris* spp. The male scale is white (hence the name "white fly") tricarinate and roughly rectangular in shape. The female scale is pale brown, inconspicuous and somewhat pear-shaped. The male scales are invariably more abundant than the females.

HABITS AND LIFE-HISTORY

All the scale insects mentioned above with the exception of the soft scale reproduce by means of eggs which are deposited beneath the scale. The female of the soft scale on the other hand gives birth to living young. The newly hatched or newly born larvæ, as the case may be, crawl around for a short time, then settle down on the leaves or bark, insert their sucking mouth parts and feed on the juices. They cover themselves with a waxy material which forms the scale or covering. The females remain stationary throughout their lives. The males on the other hand when they become mature acquire wings, emerge from their scale coverings and fly around and fertilize the females. The mature males are minute two-winged insects.

CONTROL

The safest and most generally employed method of combating scale insects is sponging with soap suds, $\frac{1}{4}$ pound of soap to 1 gallon of water, using a sponge, a cloth or a soft brush such as a cheap toothbrush. Where only a few plants are infested, they may be inverted and the stems and leaves thoroughly doused in a pail containing the soap mixture. If a piece of cloth is held tightly around the base of the plant, the earth in the pot will be prevented from falling into the pail. Two or three applications a week apart may be necessary.

Scale insects may also be kept under control by spraying the plants with common laundry soap, $\frac{1}{4}$ pound to 1 gallon of water, or with nicotine sulphate 1-400 to which a little soap has been added. It is advisable, especially in the case of ferns, to wash off the spray material about two hours after it is applied.

The spray recommended for thrips (p. 48) has been used effectively in British Columbia for controlling the Florida red scale, the hemispherical scale, and the soft scale.

As scale insects flourish to best advantage in a dry atmosphere, palms, rubber plants, ferns and crotons, should be frequently syringed with water and kept under humid conditions. It has been observed in the case of the fern scale that this insect is of no importance in humid fern houses, and only becomes troublesome on plants kept in a dry atmosphere, such as one finds in houses, stores and halls.

MEALYBUGS

Mealybugs, the well-known small, whitish, soft-bodied insects, rank among the most troublesome pests with which the florist has to contend. They are closely related to the scale insects and may be found on house plants in any season of the year. Several species occur commonly in greenhouses, viz. the

PLATE V

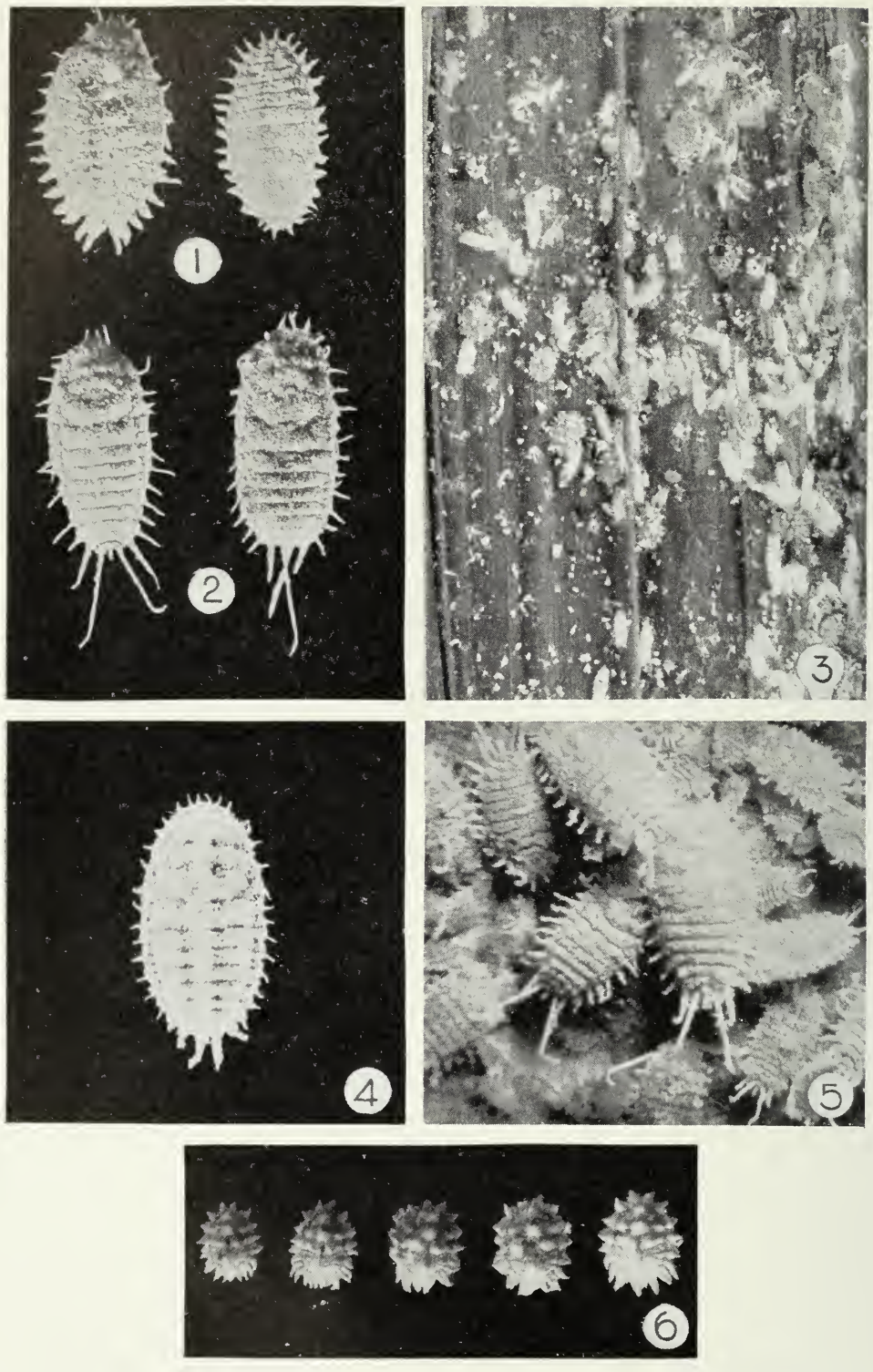


FIG. 1.—Hemispherical scale on Boston fern; 2, fern scale; 3, oleander scale on ivy 4, Mexican mealybug; 5, grape mealybug; 6 coconut mealybug; figs. 4 and 6 after Basinger, Cal. Dept. of Agr.; 5, photo by Wishart; figs. 1, 2, 4, 5 and 6 much enlarged (original).

ERRATA

The Legend under Plate IV, page 40, should read:

FIG 1.—Hemispherical scale on Boston fern; 2, fern scale; 3, oleander scale on ivy (original).

The Legend under Plate V, page 42, should read:

FIG. 1.—Common mealybug; 2, long-tailed mealybug; 3, coconut mealybug on Kentia; 4, Mexican mealybug; 5, grape mealybug; 6, coconut mealybug; figs. 4 and 6 after Basinger, Cal. Dept. of Agr.; 5, photo by Wishart; figs. 1, 2, 4, 5 and 6 much enlarged (original).

(Please cut out and paste on respective pages)

common mealybug, *Pseudococcus citri* Risso, the long-tailed mealybug, *P. longispinus* Targ., the grape mealybug, *P. maritimus* Ehr., the coconut mealybug, *P. nipae* Maskell, and the Mexican mealybug, *Phenacoccus gossypii* Towns. & Ckrl. One other species, *Rhizoecus falcifer* Kunck., known to occur on the roots of palm, is also present in Canada. Mr. G. J. Rau, of West New York, N.J., who has assisted in the investigations of this Division, writes that "the latter insect is present only on plants whose roots are well watered. They are rather small and the egg masses are usually mistaken for a fungous growth." He states further, if one knocks "off the pot of the larger palms, the presence of the insect will be indicated by the white cottony masses on the inside of the pot and on the exposed roots."

DESCRIPTION AND HABITS

These species, though similar in appearance to the naked eye, may be readily separated. The common mealybug (plate V, fig. 1) has short, stout marginal filaments; the long-tailed mealybug (plate V, fig. 2), as the name suggests, has much longer marginal filaments and in addition very long caudal filaments, frequently longer than the body; the grape mealybug (plate V, fig. 5) resembles rather closely the latter species, but the caudal filaments are only about one-half the length of the body; the coconut mealybug (plate V, fig. 6) has a "roundish convex body covered with short conical tufts of cream-coloured wax"[1]; the Mexican mealybug (plate V, fig. 4) could easily be confused with the common mealybug, but it "has the waxy covering so arranged as to give the impression of four rows of impressed dots".[1]

FIG. 22.—Egg masses and nymphs of mealybugs on bougainvillea (authors' illustration).

The females of the common mealybug deposit a large number of small, oval, pale yellowish eggs in masses, which are completely encased in a white flocculent secretion. Each female is capable of laying from 300 to over 500 eggs. The females of the grape mealybug and the Mexican mealybug, also lay large numbers of eggs. The females of the long-tailed mealybug and of the coconut mealybug do not deposit eggs, but give birth to living young.

Mealybugs occur in masses on the tender shoots and on the under and uppersides of the leaves and on the petioles. Individuals of all sizes may be found on the plants at the same time, especially on the undersides of the leaves along the midribs and near the base of the leaf stems. They injure the plants by extracting the sap, in extreme cases causing the foliage to turn yellow and drop prematurely. Infested plants are also rendered unsightly by the disgusting masses of insects and by the presence of a sooty fungus which grows in a sweet sticky liquid called honey-dew which is excreted by the bugs.

Foods Plants.—Mealybugs infest a great variety of plants; among others: coleus, fuchsia, citrus, heliotrope, geranium, palms, ferns, oleander, bougainvillea, orchids, poinsettia, hydrangea, rose, crotons, passiflora and cyperus.

[1] Basinger, A. J., Monthly Bull. Dep. Agr. Cal., XX, 1931.

CONTROL

The cheapest, safest and simplest method of combating mealybugs is to knock the insects off with a strong spray of water. Each plant should be treated individually, and the pot in which the plant is growing should be rotated by hand while the water is being applied under high pressure. Sponging and brushing with a soap-nicotine solution (see p. 7) may be resorted to when forcible spraying is impracticable.

The formula recommended for thrips (see p. 48) has been used with fair success in British Columbia.

Parasites of two of the common mealybugs, *Pseudococcus citri* Risso., and the grape mealybug, *P. maritimus* Ehr. are available for distribution, and may be obtained by applying to the Dominion Parasite Laboratory, Belleville, Ontario. As the parasites of one species of mealybug will not attack another species, it is very important that specimens of the species causing the injury be forwarded with infested parts of the plant to the laboratory at the time the request is made. Information should also be given regarding the kind of plant infested, the area infested and the night temperature of the greenhouse.

THE GREENHOUSE ORTHEZIA, *Orthezia insignis* Doug.

This insect is closely allied to the common mealybugs. It is a pest of wide distribution and attacks a variety of plants grown indoors.

DESCRIPTION AND HABITS

The adult female is about 1·5 mm. long; in colour it is usually of a dark green shade, older individuals being blackish; the body is covered with snow-white waxy plates. The males are smaller. There are several generations of the insect in the year. Different stages may be present at the same time. The female carries her eggs in a white egg-sac which is fastened to the posterior end of the body. The insect feeds by sucking the juice from the plants.

Food Plants.—Coleus, amaranthus, lantana, chrysanthemum, ageratum, and a number of other plants are freely attacked.

CONTROL

The forcible washing of infested plants with water as recommended for mealybugs is equally applicable for the greenhouse orthezia.

APHIDS OR PLANT LICE

Every florist is familiar with aphids or plant lice—the so-called "green flies" and "black flies" which infest a great variety of plants and which are generally present in all greenhouses in greater or lesser numbers at all times of the year and against which a perpetual warfare has to be waged.

DESCRIPTION AND HABITS

Several species are commonly troublesome—most of them are green in colour and others again are reddish, brown or black. They are soft-bodied, oval or globose insects with sucking mouth parts, conspicuous antennæ (feelers) and long legs. They are easily distinguished from all other greenhouse insects by the possession of two tube-like structures called cornicles which project from the sides of the abdomen near the posterior end. The adults may possess two pairs of transparent wings or they may be wingless.

Aphids feed on the tender growth of plants and by withdrawing the life juices distort the foliage and young shoots and in extreme cases partially or

wholly destroy the plants. Their presence on plants is frequently indicated by a curled and distorted condition of the leaves. They may also infest and seriously injure the flowers.

They have marvellous powers of multiplication. They reproduce parthenogenetically, that is, without the intervention of a male, and they give birth to living young. As they may commence to reproduce seven to ten days after birth and as each female may produce over fifty young, it is not at all surprising that frequently the plant lice become so numerous that it is almost impossible to insert a pin into the infested portion of a plant without touching an insect. Both winged and wingless forms are produced. The function of the winged forms is to migrate to fresh plants and establish new colonies.

Fig. 23.—Heavy infestation of aphids on stem and foliage (original).

SOME COMMON GREENHOUSE SPECIES

The Green Peach or Spinach Aphis, *Myzus persicae* Sulzer, is undoubtedly the most common greenhouse species. It is a very general feeder and attacks a great variety of plants—among others carnation, snapdragon, Easter lily, cineraria, primula, vinca, chrysanthemum, lettuce, radish and other vegetables. It is greenish in colour and has clubbed cornicles.

The Lily Aphis, *Myzus circumflexus* Buckton, infests Easter lilies, callas, arum lilies, vinca, tulips, freesia, hydrangea, maidenhair fern, chrysanthemum,

cyclamen, schizanthus, etc. It is greenish-yellow with conspicuous black markings on the abdomen, which in the case of the wingless females are shaped like a horseshoe.

The Melon Aphis, *Aphis gossypii* Glov., feeds on cucumbers, other cucurbits, begonias, etc. It varies in colour from pale to dark green and has short dark cornicles.

The Rose Aphis, *Macrosiphum rosae* Linn., as the name indicates, attacks the rose. It is a large green species with conspicuous black cornicles.

Two species commonly occur on chrysanthemums, the black aphis, *Macrosiphoniella sanborni* Gill., which has short bottle-shaped cornicles and "the small green fly" *Rhopalosiphum rufomaculatum* Wilson.

The Pea Aphis, *Illinoia pisi* Kalt, a large, shining green species, with long cornicles, commonly infests sweet peas.

The Black Violet Aphis, *Idiopterus violae* Perg., occurs on and is frequently very injurious to violets. It is a dark-coloured insect with light brown appendages, and with broad black wing veins.

APHIDS AS VECTORS OF VIRUS DISEASES

Among the insects which are responsible for the transmission of plant virus diseases, aphids or plant lice predominate. One species, the green peach aphis, *Myzus persicae* Sulz., which occurs very commonly in greenhouses, is known to be associated with no less than 21 plant viruses. Virus diseases such as mosaic of tomatoes and cucumbers, are frequently of serious concern in greenhouses and these and other similar diseases may be transmitted from plant to plant by aphids. Therefore, at all times, greenhouses should be kept as free as possible of aphids by suitable control measures. Other insects, such as thrips and psyllids, are also known to be vectors of virus diseases.

CONTROL

Aphids are easily controlled by spraying or dusting with nicotine, pyrethrum or derris preparations, or by fumigating with tobacco extracts or hydrocyanic acid gas (see p. 7). The general practice should be to spray when only a few plants are attacked and to fumigate where most or all of the house is infested. In using the commercial insecticides the manufacturer's directions should be followed.

Nicotine dusts (see p. 7) are also useful in controlling aphids.

Some growers prefer to fumigate with hydrocyanic acid gas because it is cheaper than nicotine preparations; however, the majority fumigate with tobacco because it is safer. In combating the violet aphis, hydrocyanic acid gas, or pyrethrum or derris sprays should be used, as nicotine is liable to injure violets.

Parasites and predators are important in the control of aphids. The presence of parasites can be determined by the straw-coloured or black mummies that may be seen among the colonies of living aphids. If present, their effectiveness can be assured if the mean daily temperature is maintained at 65° F. or higher. If they are not present, a stock may be obtained upon application to the Dominion Parasite Laboratory, Belleville, Ontario, giving information regarding the greenhouse conditions and the crops infested.

THRIPS

With the exception of aphids there are no insects which are more generally injurious to plants grown under glass than thrips. Species found in greenhouses are the onion thrips, *Thrips tabaci* Lindeman, a most troublesome species; the

greenhouse thrips, *Heliothrips haemorrhoidalis* Bouche; the sugar-beet thrips, *Heliothrips femoralis* Reuter; the black clover thrips, *Haplothrips statices* Haliday; the long-winged thrips, *Scirtothrips longipennis* Bagn., and the palm thrips, *Parthenothrips dracœnæ* Heeg. As the habits of thrips are, in general, similar and the remedies used in combating them practically the same, they can, conveniently, be treated as a class.

DESCRIPTION AND HABITS

Thrips are minute, elongate insects and the species which commonly infest greenhouse plants are yellowish, yellowish-brown, brown or black in colour. The adults are easily distinguished from the nymphs or immature insects by the possession of two pairs of narrow wings fringed with long, delicate hairs.

Fig. 24.—Rose buds destroyed by thrips; adult thrips below, much enlarged (authors' illustration).

They attack the foliage and flowers, and by rasping the tissues and extracting the sap and colouring matter, produce a speckled silvery effect. Badly injured leaves soon become discoloured, gradually wilt and die.

The life-history of a species which has proved most troublesome in greenhouses, namely, the onion thrips, is, briefly, as follows:—

The female has a tiny saw-like organ called an ovipositor near the posterior end of the abdomen and by means of this she makes slits in the leaf or stem and inserts minute, white eggs in the tissues. The eggs hatch in a few days and the nymphs or immature thrips soon commence to feed. The nymphs pass through four stages; the first two on the plants and the last two in small earthen cells in the soil. They transform to adults while in the soil and in this latter stage return to the plant and proceed to feed and breed. The life cycle is completed in three to four weeks.

An account of the greenhouse thrips has been published by H. M. Russell.[1] From this the following statements have been taken. The female deposits her eggs within the leaf tissue and these hatch in the greenhouse in about eight days. The larvæ which hatch from the eggs are minute, white in colour, and feed together in colonies on the surface of the leaf removing the colouring matter in the same manner as do the adults. Upon becoming full grown the nymph, or larva, changes to the resting stages (prepupa and pupa) during which time it remains more or less motionless and does not feed. These stages require periods of about four to six days, after which the adults emerge. The total time required for this insect from the time the egg is laid until the adult emerges ready to reproduce its kind is from twenty to thirty-three days, and as this insect continues active in the greenhouse the entire year many generations occur each year.

---

[1] Cir. No. 151, U.S. Bureau of Entomology.

Food Plants.—Roses, carnations, cucurbits, calla lilies, cinerarias, fuchsia, begonias, palms, azalea, chrysanthemum, phoenix and other plants are frequently seriously damaged by these insects.

FIG. 25.—Cyclamen bloom destroyed by long-winged thrips; photo by Downes (original).

CONTROL

The recommended remedies for thrips are:—

(1) Fumigation with any of the standard nicotine preparations (see page 9).

(2) Hydrocyanic acid gas fumigation (see page 7).

(3) Spray with an emulsion made as follows: coal oil, 10 ounces, water, 5 ounces, whale oil or linseed oil soap, 1 ounce. Heat the water sufficiently to dissolve the soap, then add the coal oil gradually while churning until a thick creamy emulsion is formed. For use add 3 ounces of the stock emulsion and 1 teaspoonful of nicotine sulphate (40%) to 1 gallon of water.

(4) Apply spray made by dissolving 2 ounces of tartar emetic and 8 ounces of brown sugar in $2\frac{1}{2}$ gallons of water.

THE TARNISHED PLANT BUG, *Lygus pratensis* L.

This common plant bug known also to the florist and gardener as the aster bug, is frequently very destructive in greenhouses to certain kinds of plants. In the flower garden it is troublesome almost every season, destroying the buds of dahlia, zinnia, etc.

DESCRIPTION AND HABITS

The Egg.—The egg is described by Crosby and Leonard[1] as being "0·95 to 1 millimeter in length by 0·25 millimeter in width, flask-shaped, obliquely truncate, and at the anterior end slightly curved and compressed toward the apex." There are no cases on record of the eggs having been deposited on plants in the greenhouse.

FIG. 26.—The tarnished plant bug; enlarged and natural size (after Dustan).

The Nymph and Adult.—The bug has five immature or nymphal stages, and in these stages it is mostly green or yellowish-green in colour. In the adult or perfect stage it is about one-quarter of an inch long, of a variable colour, most individuals being of a light brown colour with black and yellowish markings. In this stage it has fully-developed wings. It is a true sucking insect and both in the nymphal and adult stages is very active and wary. The winter is passed in the adult stage out-of-doors, under fallen leaves, stones, rubbish, etc. In the spring the insects emerge and feed and breed on various cultivated plants and on weeds throughout the growing season. They gain entrance into greenhouses through open doors and also probably through the ventilators.

Food Plants.—The tarnished plant bug is known to attack a great many different kinds of cultivated plants. In the greenhouse during some years it effects important injury to such plants as chrysanthemums, dahlias, carnations and asters, producing what has been called blind buds, by puncturing the blossom buds with its sucking mouth parts. In the case of single-stemmed chrysanthemums this is a serious injury.

[1] Bull. 346, Cornell Univ. Agr. Exp. Stn.

A closely allied species, *Lygus pabulinus* Linn. was found on hydrangeas imported from Belgium, in a greenhouse in Montreal, Que., in 1935. The species is widely distributed both in Europe and North America.

CONTROL

Clean Culture.—Areas adjacent to greenhouses which are kept clean of weeds, rubbish, etc., will not attract the insects as will plots and gardens which are allowed to become dirty.

Screening.—The bugs may be prevented from gaining access to plants in greenhouses, by the placing of wire cloth screens on the doors and ventilators. If it is not considered practicable to screen the ventilators, the doors at least should be screened.

FIG. 27.—Flower buds destroyed by tarnished plant bug (after Gibson).

Dust Mixture.—A heavy application of 90-10 sulphur-lime dust may be of some value in preventing tarnished plant bug injury.

Several greenhouses in Nova Scotia devoted to the growing of chrysanthemums were recently severely infested with the tarnished plant bug. Officers attached to the Annapolis Royal Laboratory reported that effective control was secured with pyrethrum 100 per cent, using a rotary hand duster.

THE FROG-HOPPER, *Philaenus leucophthalmus* Linn.

Spittle insects, known also as frog-hoppers, occur commonly on the stems and leaves of many different kinds of plants. The small, immature, brownish insects live within a mass of white froth or "spittle" which is quite conspicuous on the plants. There are a number of different species, all belonging to the family Cercopidae. They are all sucking insects, living on the sap which they obtain from the plants. Regarding species found in greenhouses in Canada. *Philaenus leucophthalmus* Linn. is the only one which has been recorded.

FIG. 28.—Froth on leaf caused by spittle insect (after Gibson).

DESCRIPTION AND HABITS

Adult.—The frog-hopper here discussed is about three-sixteenths of an inch in length, the body being broad and the head rather blunt. In colour it varies from a pale tawny yellow to almost entirely black. Some specimens have the head and front part of the body yellowish, others have yellowish spots on the wings.

Nymph.—The nymphs of frog-hoppers which live in the spittle, are smaller than the adults, short-bodied with short legs and a blunt head, and are of a creamy yellow colour. They moult several times.

The only available record in Canada of *Philaenus leucophthalmus* Linn. causing injury to plants grown under glass was made in July, 1939, when an opportunity was afforded of seeing injury to young chrysanthemum plants in a greenhouse, in St. Thomas, Ontario. Apparently the insect after leaving the spittle on plants growing outside had invaded the greenhouse. The injury where the bugs had been feeding was particularly noticeable near the tips of the plants.

Food Plants.—In the greenhouse in St. Thomas, the only plant attacked was chrysanthemum. There is a similar record in Germany. Outside, the insect has been found on timothy, alfalfa, clover, fire cherry, raspberry, and other plants.

CONTROL

If this or other species of frog-hopper, should become sufficiently troublesome in greenhouses in Canada, spraying the infested plants with nicotine-soap solution (see p. 7) would doubtless be of value.

THE BOXWOOD PSYLLID, *Psyllia buxi* Linn.

This small insect, somewhat resembling a miniature cicada, a migrant from the Old World, has been found on boxwood *(Buxus)* in a greenhouse, at Yarmouth, N.S. Two plants, both in tubs, placed in the greenhouse for the winter months, were observed in early May, 1934, by R. P. Gorham, of this Division, to be severely infested.

DESCRIPTION AND HABITS

The boxwood psyllid is greenish in colour, and in length about one-eighth of an inch. When Mr. Gorham visited the greenhouse the nymphs were covered with a white waxy secretion.

Apparently the life-history of this insect is not very well known. According to C. C. Hamilton[1] the feeding of the psyllid causes the leaves to curl "inward and in a measure form a protection for the nymphs at the tip of the twig".

CONTROL

Regarding control, Hamilton states: "If the insect becomes injurious enough to require control, thorough spraying with nicotine sulphate diluted 1 to 500 and the addition of 3 to 4 pounds of soap to 50 gallons should kill most of the nymphs." To obtain the best results, the spraying should be done just as soon as the leaves are noticed to be curling.

THE POTATO AND TOMATO PSYLLID, *Paratrioza cockerelli* Sulc.

This insect has been present in greenhouses in Medicine Hat, Alta., at least since 1928. Since that year it has become fairly well distributed in greenhouses in Alberta where tomatoes are grown. It is also known to occur outside in southeastern British Columbia and in Saskatchewan. From a circular prepared by G. F. Manson, Dominion Entomological Laboratory, Lethbridge, Alta., much of the following information is taken.

DESCRIPTION AND HABITS

The egg is elongate, spindle-shaped, yellow to orange in colour, and borne on the end of a thin stalk. Eggs may be found singly or in rows or groups on either surface of the leaves. On tomato they are frequently found projecting from the margins of leaflets, though they may also be found thus on other host plants. Each female is capable of laying 300 to 400 eggs.

The nymph, small, greyish-green, flat and scale-like, hatches from the egg about six days after it is laid. It inserts its long hair-like mouthparts into the leaf and remains relatively inactive. As the nymphs develop they cast their skins, moulting five times before emerging as adults.

The adult psyllid is about one-sixteenth of an inch long. It resembles a winged aphid but is more active. When it first emerges it is light green in colour, changing in a few days to a dark grey. Across the back is a distinct white line. When disturbed, the adult jumps as it takes off in flight. For this reason it is often called the jumping plant louse.

Food Plants.—In greenhouses in Alberta, tomato, potato, and Jerusalem cherry plants have been attacked.

The losses arising from psyllid infestation are chiefly caused by a disease known as "psyllid yellows", which occurs when the immature stages of the insect begin feeding on the plants. The actual cause of the disease is in doubt. It may be due either to a virus transmitted to the plant by the insect or a toxin injected into the plant tissues.

The first indication that plants in the greenhouse are infested with psyllids is likely to be the presence of a white granular deposit on the leaves directly below the feeding insects. In severe cases the lower leaves become sticky, favouring the growth of a grey fungus which collects dust and gives the leaves a smutty appearance.

[1] Circ. 179, 1926, N.J. Agr. Exp. Stn.

CONTROL

Whenever psyllids are observed in the greenhouse they should not be allowed to multiply and escape. Great care should be exercised in the disposal of plant waste. The material pruned from the tomato plants should always be burned as soon as it is removed. Kerosene or waste crankcase oil will aid greatly in the burning of this green material.

In order to prevent an infestation of psyllids several points should be borne in mind:—

(1) As far as possible avoid the overlapping of tomato crops.
(2) Tomato plants for a second crop should be started in an isolated part of the greenhouse as far away as possible from the producing crop.
(3) Plants of the potato family introduced into the greenhouse in the autumn should first be carefully examined for psyllids.
(4) Freezing of the entire greenhouse for a month during the coldest part of the winter has given good control of psyllids where due care has been taken to prevent the reinfestation of the house.
(5) Workmen going from an infested area in the field or from an infested part of the greenhouse to uninfested sections of the greenhouse should thoroughly brush their clothes, as psyllids are readily carried on the clothing.

If bedding tomatoes or other plants are found to be infested with psyllids they should be dipped at least three times, at intervals of one week, in the following solution:—

Fresh derris powder—1 ounce
Linseed oil soap—1 ounce
Water—1 gallon

It is essential to use a neutral soap or one with very low alkali content for best results with derris.

This solution may also be used as a spray. It should be applied frequently and at good pressure, spraying particularly the under surfaces of the leaves.

The use of calcium cyanide (see page 8) has given good control, with little or no plant injury or blighting of bloom under commercial conditions. At the strength at which it can be used safely, calcium cyanide does not kill many of the nymphs but is effective against the adults. Because of this it must be applied at intervals of about one week to ten days to prevent the newly emerged adults from laying eggs. Fumigation should be continued until no further psyllids at any stage can be seen.

BORING AND ROOT-DESTROYING INSECTS

THE ROSE MIDGE, *Dasyneura rhodophaga* Coq.

In the report of the Dominion Entomologist for the year ended March 31, 1915, a brief mention is made of the occurrence of this pest at London, Ont., specimens of the infested shoots of the variety Mrs. J. Laing having been received at Ottawa in July, 1914. This was apparently the first record of the rose midge in Canada. Two years later its presence was detected in greenhouses in Toronto. Its work was first noticed in these houses in September, 1916. The buds of the young shoots did not develop and on investigation it was found that they were being destroyed by the larvæ. The varieties of roses which had been severely injured were Ophelia, Milady and Stanley. The variety Richmond was very slightly attacked. The owner of the houses was of the opinion that the pest was introduced on rose bushes imported from Chicago, Ill. It has since been found in other places in Ontario.

As the rose midge is one of the worst pests of roses known, (see plate VI, fig. 4), florists in Canada should realize the danger of its being introduced into their houses. In 1919 it was estimated that this insect caused a loss of $12,000 in one Ontario greenhouse, and in another a loss of $6,000.

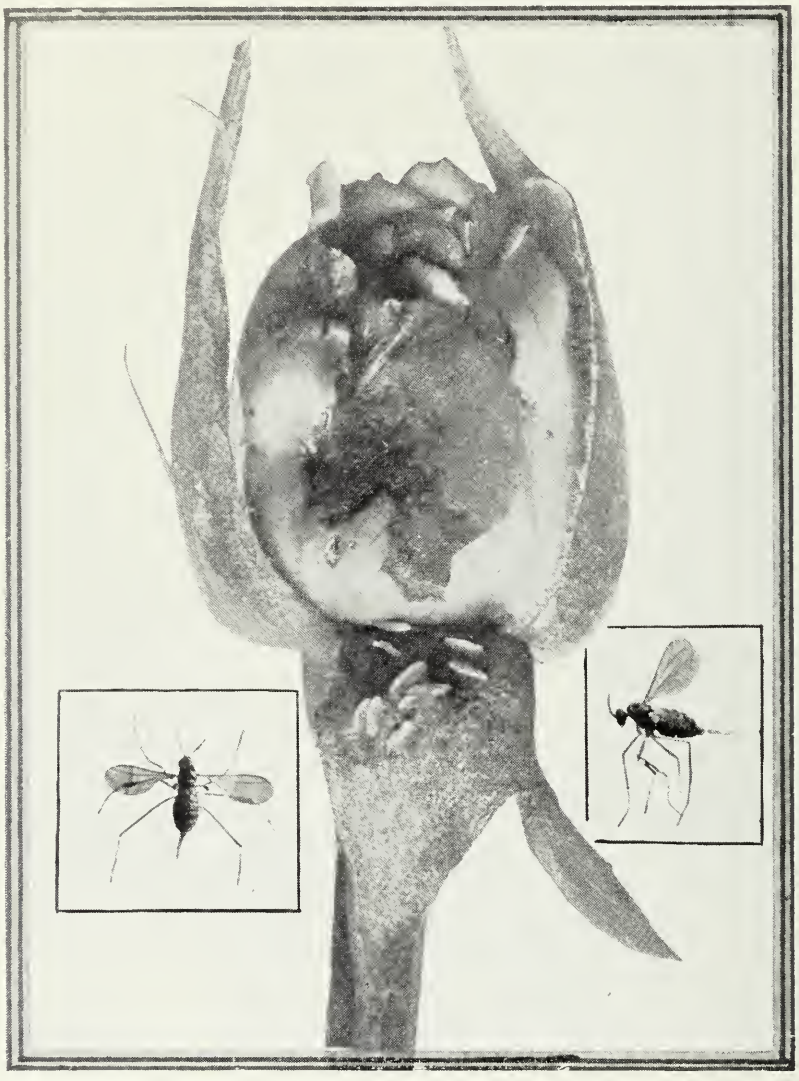


Fig. 29.—Rose midge larvæ in flower bud; adult female rose midge below, from two views; all much enlarged (authors' illustration).

DESCRIPTION AND HABITS

The Egg.—(Plate VI, fig. 3.) This is yellowish in colour and so small as to be hardly visible to the naked eye. The female deposits her eggs between the folded leaves of the leaf buds and to some extent in the axils of tender leaves and between the sepals and petals of the blossom buds. Under greenhouse conditions the eggs hatch in about two days.

The Larva or Maggot.—(Plate VI, fig. 3.) The whitish maggots on hatching at once begin to destroy the terminal leaves and blossom buds. When abundant they may be found feeding on any succulent part of the rose plant, as for instance at the bases of the flower buds, within the buds, on the uppersides of tender leaves and on leaf petioles. The favourite and usual point of attack is on the young shoot in the axil of a leaf petiole. Infested shoots grow crooked, and, as a general rule, wither and die. Affected flower buds when not killed outright may be so disfigured as to be unsaleable. In from five to seven days the maggots

become mature and then leave the plant, dropping to the soil where they change to the pupal state and emerge as adult flies in about six days. In the mature stage the maggots are tinged with red.

The Adult.—The perfect insect, or midge, is two-winged, yellowish-brown in colour and less than one-twentieth of an inch in length. Soon after the adults appear the females deposit eggs for the next generation.

The midge is most abundant and destructive during summer. With the coming of autumn it declines in numbers and by November wholly disappears from the rose plants. It remains dormant in the soil throughout the winter months and does not reappear again until early March. It is fortunate for the florist that the insect remains quiescent in the soil during the winter months, when the most profitable crops are grown. Nevertheless, the winter crops must suffer as a result of the check the infested plants receive in the summer and fall.

CONTROL

Tobacco Fumigation and Application to Soil of Tobacco Dust.—In 1916, Messrs. Sasscer and Borden,[1] of the United States Bureau of Entomology, having determined by cage experiments that a covering of tobacco dust on the rose beds would prevent the full-grown larvæ from entering the soil, conducted the following experiment in a midge-infested house in Maryland. All the rose beds were covered on October 12, 1916, with tobacco dust averaging from one-fourth to one-half inch deep. To prevent the larvæ from entering the dirt walks of the houses, all the walks were sprayed with kerosene emulsion.[2] Simultaneously, nightly fumigation with tobacco stems was begun and continued until October 30, from which date until November 8, the houses were fumigated every other night. The object of this fumigation was to kill the adult midges before the eggs were deposited. The results secured from this experiment were excellent—the midge was practically eradicated.

Application to Soil of Tobacco Dust Alone.—Following the experiments conducted in Maryland, referred to above, the value of applications to soil of tobacco dust alone, was tested in greenhouses in Ontario and it was proved that a coat of tobacco dust would not only kill the maggots which dropped from the plants but also that the nicotine absorbed by the soil from the dust would destroy the midge pupæ and larvæ in the soil. In short, the experiments indicated that in combating the midge it was not necessary to supplement the soil treatment by nightly fumigation with tobacco. In view of the cost of such nightly fumigations, the importance of this discovery is apparent. Since these preliminary experiments were conducted, it has been demonstrated under large greenhouse conditions that the insect can be completely controlled by applications to soil of tobacco dust alone. In one establishment thirty-five tons of dust were used. This work was done in mid-August. The fallen leaves on the beds were removed and the surface of the soil made as smooth as possible. The beds were then thoroughly drenched with water and a coat of tobacco dust one-fourth to one-half inch thick was applied, great care being taken to cover

---

[1] Bull. 778, U.S. Dept. Agr.

[2] Kerosene emulsion is made as follows: Kerosene (coal oil), two gallons; rain water 1 gallon; soap, ½ pound. Heat the water, cut the soap into fine shavings and add them to the water stirring till all is dissolved, then pour this into the kerosene and churn the whole violently with a syringe or force pump for about five minutes or until a thick creamy emulsion is produced. This makes the stock solution which, as it cools, thickens into a jelly-like mass. When required for use dilute with nine times its volume of warm water. The stock solution when properly made will keep for months if kept from the air.

all parts of the beds. As an additional precaution all the walks were sprayed with kerosene emulsion in order to kill any maggots which might have fallen from the plants to the walks.

From the results obtained in the above establishment as well as in other greenhouses in Ontario, there is no hesitation in recommending the tobacco dust treatment for the rose midge. Equally good results were obtained in houses where the soil was treated either in mid-July, mid-August, or September.

PREVENTION

In order to prevent the further spread of this insect, florists should be guided by the following recommendations:—

(1) Whenever possible, growers should propagate their own roses.

(2) New stock should be obtained from non-infested greenhouses.

(3) Rose plants and scions purchased through commission houses or from places not known to be free of midge, should be imported before the end of February. This recommendation is made because such stock, provided it has been planted in November or December, will not have been exposed to infection.

(4) Greenhouse-grown roses, brought in later than February, should be carefully examined for rose midge injury, and any infested plants should be destroyed. In addition to this, the soil should be washed off the roots of the plants and should then be thrown into the furnace or scalded with hot water or steam.

THE CHRYSANTHEMUM MIDGE, *Diarthronomyia hypogaea* F. Lw.

In 1915, the chrysanthemum midge was found to be thoroughly established in a large greenhouse at Ottawa. It had undoubtedly been introduced on some chrysanthemum plants imported from the United States. In addition to the Ottawa infestation, there was received in the same year, infested material from a florist in Victoria, B.C. This last infestation was first noticed in August, 1915, on chrysanthemums growing outside as well as within the greenhouse.

Since 1915 the insect has become pretty well established throughout the Province of Ontario and it has also been found in greenhouses in the Provinces of British Columbia, Quebec and Nova Scotia.

The chrysanthemum midge is of European origin.

DESCRIPTION AND HABITS

The Egg.—The egg is very small and reddish-orange in colour. Measurements of ten eggs gave the following average: length 0·275 mm., width 0·079 mm. A female midge kept under observation at Ottawa was most active, running about on the new leaves, the favourite places chosen for egg-laying being the leaf hairs near the crevices between the young forming leaves. Eggs were also found near the tip of another plant, along the surface of the leaf among the leaf hairs. On one occasion (Oct. 27, 1916), in an Ottawa greenhouse, a string of extruded eggs was found attached to a dead female which had not been able to free itself from the gall and other eggs laid among the leaf hairs were present on the gall. Altogether forty-four eggs were counted. From observations at the Vineland Entomological Laboratory, Mr. W. P. Garlick made the following notes:—

"The eggs are laid by the female usually within the space of a few hours after emergence. They are deposited to some extent on expanded leaves,

PLATE VI

THE CHRYSANTHEMUM MIDGE, *Diarthronomyia hypogaea* F. LW., AND THE ROSE MIDGE, *Dasyneura rhodophaga* Coq.

FIG. 1.—Galls on leaves of chrysanthemum, resulting from the attack of the chrysanthemum midge; 2, chrysanthemum midge, much enlarged; 3, egg, larva and puparium of the rose midge; 4, showing rose bud destroyed by larvæ of the rose midge. (Figs. 1, 2 and 4 after Gibson; 3, redrawn after Webster).

petioles and lateral buds, but most of them are laid between the petioles of the unexpanded leaves of the terminal buds. They are frequently numerous enough to give a distinct reddish colouration to the parts of the plant on which they are laid. Under greenhouse conditions, the average period of incubation of six lots of eggs was three and one-third days, the minimum and maximum being respectively two days and four days."

The length of the egg stage is stated by Weigel and Sandford[1] to vary from three to sixteen days. Females dissected during studies, gave counts of from 128 to 156 eggs per female.

The Larva or Maggot.—The larva is very similar to that of other cecidomyids; in colour it is yellowish, or yellowish-orange; in shape plump, rounded at either end, the segments being distinct; in length about 1 mm. The above mentioned authors state that the maggot upon hatching moves about on the surface among the plant hairs for a period of from one to three days, preparatory to boring into the tissues. As a result of this attack an irritation is produced which results in the production of swellings or galls on the plant containing the developing maggots and pupæ. This attack may occur commonly on various portions of chrysanthemum plants. In the Ottawa greenhouse, the galls were abundant on the leaves, stems and buds. The galls at one time were so abundant on some young plants as to entirely deform them, as a result of which development was largely stopped and no flowers borne. Many single-stemmed plants showed conspicuous malformation of the stem, resulting from early attack of the insect. In material received from British Columbia the galls were found freely on the stems and leaves. On some of the terminal leaves, the presence of the insect in conspicuous numbers had prevented growth and the leaves were clumped together in more or less rosette fashion. As a general rule there is only one larva in each gall, but occasionally compound galls with two or three compartments are found with a larva in each compartment.

The Pupa.—When the maggot becomes mature it changes to the pupal state within the gall. The pupa is about 1.25 mm. in length; the abdomen is whitish or pale yellowish; thorax and wing-covers pale yellowish-brown, cephalic horns distinct, eyes showing black; leg-cases whitish or pale yellowish.

The Gall. (Plate VI, fig. 1).—This is a conspicuous oval-shaped swelling in length from about 2 mm. to 2.5 mm. It is often slightly paler than the colour of the leaf, bud, or stem upon which it occurs, but on some plants particularly on the stems, it is concolorous and inconspicuous. In experimental tests from 13 to 16 days elapsed from the time the eggs were laid until the appearance of the galls (average 14 1-3 days). After the flies have emerged the galls are more readily seen, particularly on the older leaves, owing to their having turned yellowish or whitish in colour.

The Adult (Plate VI, fig. 2).—The midge is a small two-winged fly; the average length of the bodies of seven male individuals was 1·61 mm. and that of six females, 2·19 mm. The wings are transparent, the margins being light yellowish. The body is mostly of an orange colour, the legs yellowish.

Observations made at the Vineland laboratory indicated that most of the midges emerge from the galls in the small hours of the morning, very few being seen to issue after 9 a.m. The duration of the life-cycle from egg to adult, of specimens kept under observation, varied from 29 to 44 days.

Food Plants.—In the Ottawa greenhouses seemingly all varieties of chrysanthemums were attacked. A large number of different varieties were being

[1] Bull. No. 833, U.S., Dept. of Agriculture.

grown and the kinds which were noted to have been most freely attacked were the following: Chrysolora, Naomah, Radoelii, Ramapo, Hortus, Tolsoms, Mrs. Clay Frick, December Gem, Madam G. Rivol, Dr. Enguehard, Anna, Pacific Supreme, Early Snow, Elberon, Ursula Griswold, Aesthetic and Etherington. The varieties Bob Pulling, Gertrude Peers, Daily Mail, Oconta, Mrs. G. C. Kelly, W. Wood Mason, F. T. Quilleton, and E. T. Quittington were fairly free from injury. In addition, in other Ontario greenhouses Major Bonnaffon has been completely destroyed and other varieties attacked were: White Chieftain, Bronze Brighthurst, Celtic, Mrs. Godfrey, La Africana and Pink Star.

In the Victoria greenhouse these varieties were infested: Smith's Advance, Halliday, Ivory, Polepheum, Chrysolora, Bonnaffon, Wm. Turner, Western King, Mrs. Thompson, Enguehard, various pompons. Of these varieties Smith's Advance, Ivory, Bonnaffon, Wm. Turner, Western King, and Enguehard were practically ruined.

Felt states that the insect has been recorded from central and southern Europe as infesting *Chrysanthemum leucanthemum, C. corymbosum, C. atratum, C. japonicum* and *C. myconis*. In America the pest was first noticed on the variety known as Mistletoe.

CONTROL

The chrysanthemum midge has been not only controlled but wholly eradicated in certain greenhouses in Ontario and also in the United States by thoroughly spraying infested plants with the following mixture:—

Nicotine sulphate (40%) ..... $1\frac{1}{4}$ teaspoonfuls
Soap ..... 1 ounce
Water ..... 1 gallon

The spraying should be done every second day for a period of about six weeks, or in other words as long as any living insects remain in the galls. The mixture destroys the eggs, but it is applied primarily to kill the emerging adults. For this reason, and in view of the fact that the adults emerge during the night, it is advisable to do the spraying as late in the afternoon as possible.

In a badly infested greenhouse in southwestern Ontario, the chrysanthemums were sprayed as outlined above, commencing about the middle of January, and the midge was wholly eradicated. On some varieties, the consistent spraying caused a yellowish discoloration of the leaves; the plants, however, soon outgrew this injury and became healthy and vigorous.

The midge may also be controlled by fumigating nightly for a period of at least six weeks with either nicotine or cyanide. As the adults are very easily killed, these materials should be used at one-half the usual strength. The fumigation should be done at midnight in order to kill the newly emerged flies before they lay any eggs.

As the midge can apparently only be introduced on new stock, a practice should be made of carefully examining all such stock and of burning any which is or appears to be infested with midge.

THE BLACK VINE WEEVIL, *Brachyrhinus sulcatus* Fab.

This insect, to which the name "black vine weevil" has been given, is better known among florists as the cyclamen grub. Injuries in greenhouses have been reported from the Provinces of British Columbia, Ontario, Quebec, and Nova Scotia. In the Montreal district it has been particularly destructive of late years and has caused important losses especially to cyclamens.

FIG. 30.—Cyclamen plant showing injury to corm by the grubs of the black vine weevil; note stunted appearance of plant owing to roots having been eaten (authors' illustration).

DESCRIPTION AND HABITS

The Egg.—The egg of this weevil is almost spherical in shape and white in colour at first, changing later to brown. The eggs may be introduced into greenhouses in soil used for potting; more likely, however, they are deposited around the crown of the plant by weevils which have gained entrance to the house.

The Larva or Grub.—The larva is legless, of a yellowish-white colour with a pale brownish head, and when mature is about three-eighths of an inch long. The upper surface of the body is covered with short reddish hairs. It lives entirely in the soil and in the case of cyclamen plants to which the chief injury in Canada has been caused, the accompanying illustration shows the damage it may do.

In serious infestations the roots are entirely eaten and in addition large cavities are eaten out of the corm. Under such conditions the growth of the plant is arrested, it becomes stunted and eventually dies.

FIG. 31.—Black vine weevil; grub at left; adult beetle in centre; pupa at right; hair lines indicate natural size (authors' illustration).

The larvæ have been found in greenhouses throughout late autumn, winter and early spring months. When the grub is mature it makes an earthen cell within which it changes to the pupal state. These cells are about five-eighths of an inch long by about three-eighths of an inch wide. One larva, however, kept under observation pupated on the surface of the soil just below some dead leaves from the infested cyclamen plant without making an earthen cell. Others pupated normally in the soil at depths varying from one-half inch to one and one-half inches.

The Pupa.—The pupa is white, smooth, and in length about three-eighths of an inch.

The Beetle.—The adult insect, one of the snout beetles, is black in colour, with patches of yellow hairs on the wing-covers which show up as spots. In length it is about three-eighths of an inch. The wing-covers are united and for this reason the beetle cannot fly and can only gain access to plants by walking.

Food Plants.—In Canada the insect has been found attacking the following plants in greenhouses: cyclamen, gloxinia, adiantum, begonia, and several varieties of primula. Out-of-doors, saxifrage, polyanthus and primula have been attacked; the insect in some sections of Nova Scotia and British Columbia is a rather important pest of strawberries and other plants.

CONTROL

Protection of Plants from Beetles.—Owing to the fact that the beetles cannot fly, it would seem that protection from the egg-laying females could be had to an important extent by using barriers of tanglefoot. Boards of one inch thickness and six inches high, in length and width to fit the benches or beds, could be fastened together at the ends, the framework placed an inch or so in the soil and the upper outside edge covered with tanglefoot to prevent the beetles from gaining access to the enclosure containing the plants. To protect clothing a strip of thin wood two inches wide could be nailed to the top of the framework. If the benches do not touch the walls of the greenhouse an overlapping strip of tin fastened to the edge of the bench, extending outwards about 2 inches and

downwards at right angles to the same depth, will prevent the weevil gaining access to the benches.

Poisoned Bait.—The adult weevils may be destroyed by spreading thinly in infested places a bait composed of 10 lb. raisins, 1 lb. sodium fluosilicate (or 1½ lb. sodium fluoride), and 10 lb. shorts. The raisins should be soaked in 2 pints of water until the water is absorbed. They should then be coarsely chopped in a household food chopper and added to a mixture of the shorts and sodium fluosilicate (or sodium fluoride). The whole mixture should be stirred or rubbed between the hands until the shorts has taken up all the juice. The bait should be sufficiently moist to form a ball when squeezed by hand.

WIREWORMS

In April, 1938, wireworm larvæ were found in a greenhouse at Niagara Falls, Ont., boring in the stems of tomato. The species concerned have been identified as *Agriotes mancus* Say and *Melanotus* sp.[1] Both species were present in the greenhouse at the same time. These insects, important enemies of vegetable crops in the Eastern Provinces, are not commonly a pest in greenhouses in Canada.

Fig. 32.—A wireworm slightly enlarged and about half size (after Gibson and Twinn).

DESCRIPTION AND HABITS

Wireworms are slender, tough, yellowish, or reddish-brown creatures, about an inch or so in length when full grown. The life-history of these insects is extended over several years. The adult insects developing from the wireworms are known commonly as click beetles. These latter under outside conditions, hibernate in protected places, and on emerging in spring, the females lay their eggs in the soil, usually of grasslands. Several years are required to complete the larval stage. When the larvæ are mature, they change to the pupal state from which, in due course, the adult beetles emerge.

Food Plants.—In greenhouses in the United States, wireworms are known to have caused injury to carnation, chrysanthemum, wall-flower, pansy, cyclamen, snapdragon, sweet alyssum, stock, and violet. There are no records of any of these plants being injured in Canada, the only infestation which has come to notice being to tomato as mentioned. Important losses from wireworms to tomato plants grown under glass have occurred in England.

CONTROL

Baits.—Under garden conditions, it is claimed that wireworms may be trapped by placing slices of raw potato in the soil, at a depth of 2 or 3 inches and about 10 feet apart in all directions. These should be collected once a week and all wireworms attracted thereto removed and destroyed. Rice shorts,

[1] Determined by R. Glen.

moistened and rolled into balls about the size of a small orange, and placed as mentioned above, has also been used as a bait.

Sterilization.—Soil known to be infested with wireworms, or other insects, should be sterilized as soon as the crop is removed. Precautions should be taken to see that no additional infested soil is brought into the greenhouse.

FUNGUS GNAT MAGGOTS

Certain of the fungus gnat maggots of the family Mycetophilidæ are known to feed upon the tender roots of potted plants. Many complaints have been received from various parts of Canada, of the maggots being present in conspicuous numbers in the earth in which plants had been growing. A few of the species have been reared to the adult flies. These latter are very small greyish or blackish two-winged flies, which may be seen frequently around potted plants.

Sciara coprophila Lint.—This species has been reared from larvæ received from Winnipeg, Man., where in December, 1920, it was found in large numbers in mushroom beds. The species has also been received from greenhouses in Sudbury, Ont., (March, 1917), where the larvæ were abundant in the soil among the roots of ferns, begonia, erica and anemone. Hungerford[1] records undoubted injury by the larvæ—to geranium, begonia, fern, coleus, etc. He states that the female flies lay from about seventy-five to one hundred and seventy-two eggs, these being placed in crevices in the soil; they hatch in six days. The maggots are whitish in colour and when full grown are about 7 mm. in length. The pupal stage lasts from five to six days. The adult fly is two-winged, the body being dark brown or blackish in colour; in length it is 2·5 mm.

Sciara munda Joh.—Female adults apparently of this species were present in large numbers in March, 1918, in important violet greenhouses at Brampton, Ont. No evidence was received indicating damage by the maggots to the root system. It is a larger species than the foregoing, measuring 3 mm. in length.

Sciara prolifica Felt.—In 1899, the senior author found the adults of this species in violet houses in Toronto, Ont. No injury was noticed to the plants, nor did the grower have any evidence of damage. This fly is a conspicuous species, about the same size as *S. munda*.

Pnyxia scabiei Hopk.—This species was reported in 1932, by G. J. Spencer, as occurring in large numbers in the soil of greenhouses in Vancouver, B.C. Growers were of the opinion that the damage to crops, particularly mushrooms, planted in the infested soil, was especially noticeable in autumn.

CONTROL

As soil containing dried blood appears to be particularly inviting to fungus gnats, the use of fertilizers containing this material should be avoided in greenhouses infested by these insects.

Soap Suds.—On occasions it has been recommended to treat soil infested with these maggots with strong soap suds. Some correspondents have reported favourably on this method of control. One correspondent reported that an infested pot was placed "in a large pail containing strong soap suds, so that the water just reached the top of the soil; it was left there for a few hours, drained well afterwards, and since, no more worms have been seen".

Corrosive Sublimate.—Spraying the soil where these insects are present with corrosive sublimate, 1 ounce in 10 gallons of water, is recommended. Dissolve the

[1] Jour. Econ. Ent. IX, 538.

corrosive sublimate in a quart of hot water, then dilute to the 10 gallons. Wooden, glass or earthenware vessels only should be used in mixing. Every care should be taken in using this material as it is a deadly poison. All containers should be washed thoroughly after use.

Tobacco Dust.—Mulching the soil with tobacco dust will also kill these insects.

STRAWBERRY ROOT WEEVIL, *Brachyrhinus ovatus* L.

This important pest of strawberries, particularly in British Columbia, is also found commonly in the Eastern Provinces, where it has been complained of, chiefly from its habit of entering homes. In British Columbia, in addition to the damage the weevil does to strawberry and other plants, it has also been found attacking the flowers of tuberous begonias growing in a greenhouse. W. Downes, in charge of the Dominion Entomological Laboratory, Victoria, B. C., reported that serious damage had resulted from the infestation. The weevils fed upon the young flower stems causing them to drop off.

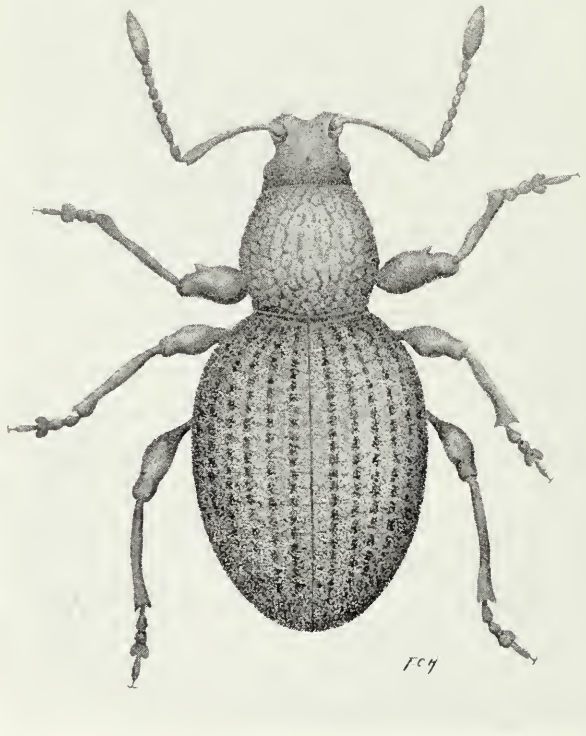


FIG. 33.—The strawberry root weevil, greatly enlarged (after Downes).

DESCRIPTION AND HABITS

The strawberry root weevil is about one-quarter of an inch in length and in appearance as shown in figure 33. The beetle is without wings and, therefore, cannot fly. It gains access to houses by walking.

CONTROL

Mr. Downes reported that one application of the raisin-shorts weevil bait (see page 62) effected complete control.

THE NARCISSUS BULB FLY, *Merodon equestris* Fab.

In Eastern Canada, the damage caused by the maggot of this fly is apparently limited to losses of imported narcissus bulbs in which the larvæ are present, but in British Columbia where the fly has become established and breeds in the open, damage may result from transferring bulbs from the garden to the greenhouse. The loss here, also, is due only to the destruction of infested bulbs, as, so far as is known, the flies do not breed under glass. Under field conditions in British Columbia, one florist lost 50,000 narcissus and daffodil bulbs in one year. The insect is of European origin, having been described from Italy. It is also known to occur in England, Holland and other European countries.

DESCRIPTION AND HABITS

The adult fly is from one-half to five-eighths of an inch long and resembles a small "bumble bee" in appearance and actions. It varies in colour considerably but is usually tawny yellow, banded with black. The egg is very small, oval in shape and white in colour. The larva or maggot is whitish or yellowish in colour and when full grown is from one-half to three-quarters of an inch in length. The larva pupates in the bulb or in the soil nearby.

Fig. 34.—Narcissus bulbs infested with larvæ of narcissus bulb fly; bulb at left opened to show larva and its work (authors' illustration).

The eggs are usually laid in the soil, very rarely on the stems or leaves. The young larvæ bore into the bulb and feed upon the tissues, which they rasp or tear apart by means of strong, hooked mouthparts, the result being that the centre of the bulb is usually hollowed out. The bulbs usually become soft and, in cases of imported bulbs at least, frequently rot. In the greenhouse, the adult flies appear in January, but may occur during December and possibly February.

Food Plants.—"The bulbs attacked include the narcissus, hyacinth, tulip, amaryllis, habranthus, vallota, galtonia, scilla and leucojum. As regards narcissus it has been considered by a leading grower and authority on *Merodon* that the hard bulbs of the *N. maximanus* and *N. spurius* type are least attacked, while the most susceptible are the *N. poeticus* and *N. Leedsi* varieties, and, further, that varieties with coloured cups are more susceptible than those without."[1]

[1] Leaflet No. 286, Board of Agriculture and Fisheries (London, Eng.)

CONTROL

Sound bulbs only should be planted. Any that appear soft upon pressure should be discarded. To avoid transferring infested bulbs to the greenhouse they should be lifted and dried as soon as the tops are withered and treated to destroy the larvæ as soon as possible. If treatment is delayed the maggots will have grown larger and penetrated more deeply into the bulbs, in which case they would be harder to destroy. If they have penetrated no deeper than the basal plate, the bulb can be saved and will flower the following season. The small entrance hole made by the larva can be found by scratching the base with a knife blade or a very stiff brush.

Hot Water Treatment.—This has been found one of the most effective methods of control. The bulbs are soaked in hot water at a temperature of 110 degrees Fahr. for one hour. If the stem or bulb nematode[1] is also present soaking must be continued for 2½ hours. Some method of keeping the water at that temperature must be used and the heat must on no account be allowed to rise temporarily more than one degree or injury to the bulbs will result. Where large quantities of bulbs are to be treated annually proper apparatus with thermostatic control of the water temperature should be used. After treatment the bulbs should be thoroughly dried or planted at once.

THE LESSER BULB FLY, *Eumerus strigatus* Fall.

This European insect was first found in Canada in 1904[2]; in fact this year is evidently the first record of the finding of the species in America. In Canada, the insect has been found in greenhouses in both the larval and the adult stages in the Provinces of Quebec and British Columbia. Outside, the species has also been taken in the Provinces of Ontario, Manitoba and British Columbia. In addition to the above popular name, it has also been called the bulb moon-fly, and the lunate onion fly.

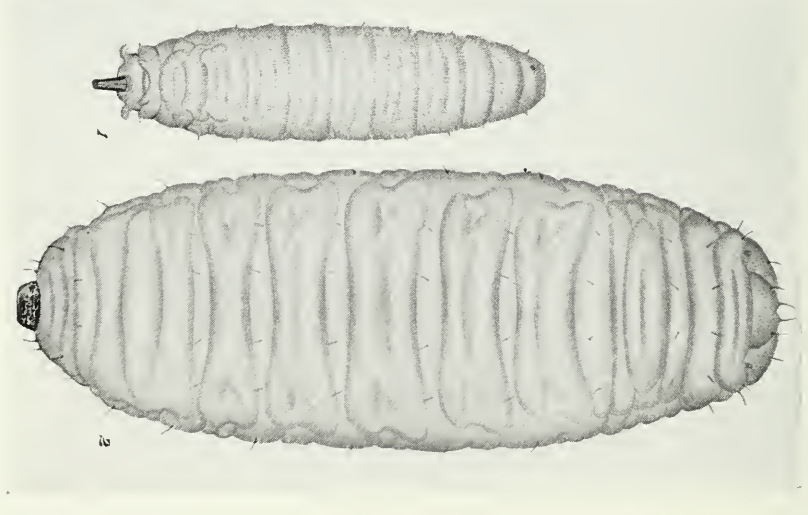


Fig. 35.—1, maggot of *Eumerus;* 2, maggot of *Merodon;* both much enlarged (after Gibson).

DESCRIPTION AND HABITS

The Larva or Maggot.—The larva has been described by MacDougall[3] as "half an inch and over when full grown. It is greyish-yellow in colour and

[1] *Anguillulina dipsaci* Kuhn.
[2] Canadian Entomologist, XLIX, 190.
[3] Journal of the Board of Agriculture (London, Eng.), 1913.

has a distinctly wrinkled appearance. The mouth parts are brown and the respiratory processes at the front end are brownish-red. The rounded hind end is brown at the tip and has a projection on each side with a process which ends in the breathing pores between the projections."

Theobald[1] has found as many as seventeen larvæ in one bulb and states that "there is no doubt that these small narcissus and other bulb flies are the cause of much loss, but are not, it seems, so widely spread as *Merodon;* still the number one finds in samples of bulbs purchased shows that it has to be dealt with just as much as the larger maggot."

In October, 1910, the late Dr. C. Gordon Hewitt found the larvæ abundant in a greenhouse in Victoria, B.C. The owner of the greenhouse in the same year reared the adults from narcissus bulbs, the dates of emergence being April 7 to 9.

"In an advanced stage of the attack, the interior of the bulb is entirely destroyed and is full of a semi-liquid decaying mass. The attack seems to begin at the neck, and in mild cases, the larvæ are found in the neck or under the scales at one side. The presence of many larvæ and the complete decay produced distinguishes the damage done by *Eumerus* from that done by *Merodon*."[2]

The Adult.—The fly is much smaller than the narcissus bulb fly, being about one-quarter of an inch in length. It is blackish-green in colour with white marks on the sides.

Food Plants.—This insect has been recorded as a pest of onions, shallot, roots of iris and bulbs of narcissus, hyacinth and amaryllis.

CONTROL

As field observations made in British Columbia indicate that this insect preferably infests diseased or damaged bulbs, it is important that all such bulbs be removed and destroyed. Otherwise, the methods of control for the narcissus bulb fly may be adopted.

THE CATTLEYA FLY, *Eurytoma orchidearum* Westw.

Reports of injury in Canada by this insect have been comparatively few, and those on record refer to infestations found in the Provinces of British Columbia and Ontario. The insect is also known as the orchid fly and the orchid isosoma.

DESCRIPTION AND HABITS

The adult insect is a small four-winged fly, less than one-eighth of an inch in length, with a black body. Regarding the oviposition habits of the female, Davis[3] states that the egg is placed in the centre of the small flower-bulb near the base, and the small larva hatching later, feeds on the tissues and burrows out a small cavity in the centre, the embryo flower-bud within being thus destroyed. Although the female usually inserts several eggs in a bulb, each one is deposited singly. The small, individual cavities, as they are enlarged by the larvæ, merge into a single larger burrow. When full grown

---

[1] Report on Economic Zoology for year ending Sept. 30, 1911.
[2] Leaflet No. 286, Board of Agriculture and Fisheries (London, England).
[3] 27th Rep. State Ent. Illinois, 1912.

the larva changes into a whitish pupa and later to the adult insect, which in due time escapes from the bulb. The infested bulbs, of course, fail to produce flowers.

Food Plants.—Orchids of the genus *Cattleya* are attacked.

Fig. 36.—Cattleya fly, enlarged and natural size (original).

CONTROL

In houses where this insect is found, control may be obtained by fumigating once a week with nicotine (see page 9). This fumigation which is intended to destroy the adult flies, should not be carried on when any of the orchids are in flower, owing to the fact that the concentration of nicotine necessary to kill the flies will undoubtedly injure the flowers.

Buds which are found to be infested should be removed and destroyed by burning.

ROOT MAGGOTS

In the Province of British Columbia, greenhouse-grown carnations have been attacked by two species of root maggots, namely, *Hylemyia brunnescens* Zett. and *H. florilega* Zett. Regarding the former species, reference to an outbreak in 1927 at New Westminster, B.C., was recorded by G. J. Spencer,[1] who stated that considerable damage had been effected to the stems and roots. In the same year, and also in 1930, young carnation plants grown in greenhouses of the University of British Columbia, at Point Grey, were destroyed, the work of the maggot being much the same as that of the cabbage root maggot. The other species, *H. florilega* Zett., was also reared from the same material.[2] This latter species was reared at Ottawa, from *Dianthus*, grown in the open

[1] Proc. B.C. Ent. Soc. No. 25, 1928.
[2] Proc. B.C. Ent. Soc. No. 30, 1930.

by the late James Fletcher, in June, 1886. *H. brunnescens* Zett. was reared in June, 1929, at Agassiz, B.C., by R. Glendenning, from *Dianthus* growing in the open.

DESCRIPTION AND HABITS

The Larva or Maggot.—Root maggots of the genus *Hylemyia* are, in general, similar in appearance. They are about one-third of an inch in length when full grown, whitish in colour, flattened at one end and tapering to the other or head end.

The Puparium.—When a maggot reaches full growth it changes to a brown-coloured object, about one-quarter of an inch in length, known as the puparium. This is simply the hardened contracted skin of the maggot.

The Adult Insect or Fly.—The flies are dark in colour, smaller than the common housefly.

Very little is known about the life-history or habits of the above two species. These, in general, are probably similar to those of the cabbage root maggot.

FIG. 37.—Carnation plants destroyed by the root maggot, *Hylemyia brunnescens* Zett. A, normal stem; B, B. stem tunnelled and broken by maggots; C, normal young root system; D, D, root system destroyed by maggots (after Spencer).

CONTROL

Sweetened Arsenical Spray.—The Division of Entomology has had no opportunity of testing the value of any control measures for these root maggots, but in correspondence Professor Spencer suggests the use of a sweetened arsenical spray, following observations which indicate that the adult flies "scatter all over the beds and apparently drink water from foliage." A formula suggested is: water, 1 gallon; molasses, 1 pint; lead arsenate, 3½ teaspoonfuls.

ANIMAL PESTS OTHER THAN INSECTS

THE COMMON SPIDER MITE, *Tetranychus telarius* Linn.

The well-known spider mite, better known by the name red spider, is a common greenhouse pest. This mite occurs abundantly on a great variety of plants and multiplies rapidly under warm, dry conditions.

DESCRIPTION AND HABITS

The Egg.—This is very small, pale in colour at first and round or spherical in shape. The female mite deposits her eggs chiefly on the undersides of the leaves. A single female is known to have deposited as many as ninety-four eggs. As they develop they change colour, becoming reddish in shade. The eggs hatch in from five to seven days.

Immature and Adult Mite.—The young mite is of a pale pinkish colour with six legs. After the first moult, however, it has the normal number of legs, namely, eight. In the later stages the mite is in general similar in appearance. The adult mite is very variable in colour. Ewing[1] in his important contribution on this insect says:—

"Six colours can be easily recognized in our common spider mite, viz., green, yellow, orange, carmine, black and brown. Of these six colours, each of the first three may be generally distributed over the whole body, so that the entire individual looks either green or yellow or orange."

Fig. 38.—Foliage of sweet pea injured by common spider mite; adult of spider mite below, much enlarged (authors' illustration).

The mites feed chiefly on the undersides of the leaves, where they insert their piercing needle-like structures into the tissues and withdraw the liquid contents of the leaf cells. After an attack the leaves lose their colour, assuming a whitish or bleached appearance; when the infestation is severe all the leaves may eventually shrivel and die. In the adult state particularly, the mite spins considerable silk. If the underside of an infested leaf is examined it will be seen to be covered by many strands of fine silk which have been spun in all directions by the mites. On one occasion a serious infestation in a large greenhouse in eastern Ontario was examined where the mites had developed to a remarkable extent and had spun large quantities of silk over the entire heads of magnificent single-stemmed chrysanthemums.

---

[1] Bull. No. 121, Oregon Agric. Exp. Sta.

As mentioned above, the mite develops rapidly in warm dry situations, frequently so in houses where flowering plants are being forced and under conditions where care must be exercised in watering.

Food Plants.—The mite is found on a large number of plants grown indoors. Carnation, chrysanthemum, violet, rose, fuchsia, geranium and other plants are frequently injured.

CONTROL

Sulphur-soap Mixture.—This is made as follows: Flowers of sulphur 1 ounce; laundry soap 2 ounces; water 1 gallon.

Dissolve the 2 ounces of laundry soap in one gallon of water, then add 1 ounce of flowers of sulphur and spray the mixture in such a way as to reach the undersides of the leaves where the mites are feeding. A short-angle nozzle will be found of value in forcing the spray well up among the foliage. Several sprayings a week or so apart may be necessary. A large grower of chrysanthemums and roses in Eastern Canada secured control by using the following mixture: soap flakes, 10 oz.; sulphur, 5 oz., water 10 gal. The spray was applied in the early afternoon, at a temperature of 50° F. for chrysanthemums and 70° F. for roses.

Oil Spray.—Spraying with a commercial summer oil emulsion, 1 per cent actual oil, to which soap has been added at the rate of 2 ounces to every 5 gallons should destroy all stages of the mite, but its use is attended with some danger to the plants, and in most cases not more than one application should be made.

Water.—It has been the general experience of florists that forcible and frequent spraying with water alone will do much to hold this pest under control.

Destruction of Infested Plants.—Badly infested plants should be destroyed as soon as they are noticed. This is best done by burning.

THE FLAT MITE, *Tenuipalpus lineola* Can. and Fanz.

In April, 1922, another species of mite was found in an Ontario greenhouse feeding on *Acuba japonica*, and causing injury similar to that of the common spider mite.

DESCRIPTION AND HABITS

The mite is dark reddish in colour, pear-shaped, and is barely visible to the naked eye (0.26 mm x 0.16 mm). Its characteristic flatness and the fact that it does not spin silk over the attacked leaf, readily separate the species from the common spider mite.

The red, sub-cylindrical eggs are laid in small clusters on the leaf.

Food Plants.—In the United States, the flat mite occurs on citrus trees and on certain greenhouse plants.

CONTROL

The remedial measures recommended for the common spider mite would no doubt prove equally effective in controlling the flat mite .

SOWBUGS

Sowbugs, or wood lice so-called, are not insects but true crustaceans. They are often very destructive in greenhouses, being commonly found along the edges of beds, under decaying boards, etc. Species which have been reported are *Armadillidium vulgare* Latr., *Porcellio scaber* Latr., and *Tracheoniscus* sp.

DESCRIPTION AND HABITS

These creatures are dark grey in colour and of an oval, flattened shape. They prefer dark situations where decay is taking place. They feed chiefly during the night.

Food Plants.—There are records of their having attacked orchids and ferns, of checking the growth of carnations and sweet peas, of injuring begonia and coleus cuttings, and of destroying the seedlings of asparagus, primula, petunia, lobelia, solanum and other plants.

CONTROL

Preventive Measures.—In combating these pests, it is important to deprive them as much as possible of hiding places. Discarded flats, old boxes, hay and other debris which harbour wood lice should not be permitted to accumulate beneath benches or around the house. All such refuse should be burned.

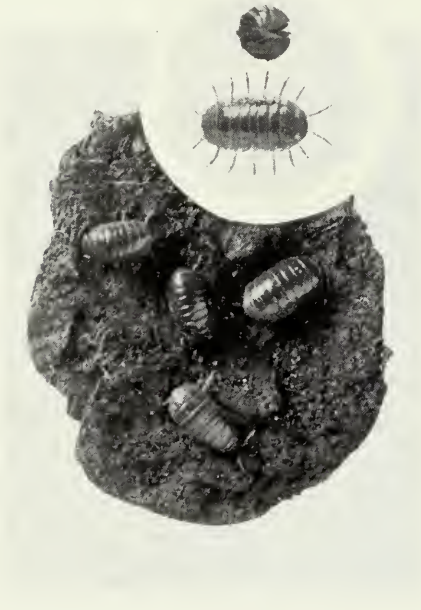


FIG. 39.—Sowbugs feeding on manure; natural size in circle (original).

Another preventive measure of value is the coating of benches with a tar composition. The tar preserves the wood and thus robs the sowbugs of a favourite refuge—damp rotten wood—and while fresh it acts as a repellent.

Hot Water.—Many sowbugs may be killed by pouring hot water into the cracks and crevices in wooden partitions and benches, by applying it along the edges of greenhouse beds where large numbers of the creatures lie concealed, and by flushing cleared benches and the ground beneath them with it. This method of control can be used to greatest advantage in establishments where the water system can be temporarily connected with a boiler or where the steam or hot water pipes can be tapped.

Trapping.—Systematic trapping by means of inverted flower pots containing damp hay will very materially reduce the pests. The traps should be examined in the morning and the sowbugs destroyed.

Poisoning.—Various poisoned baits are of value in controlling sowbugs. The two following have been tested by commercial growers and have been found to be effective:

(1) Paris green.....1 part by weight
Icing sugar.....10 parts by weight

(2) Paris green.....1 part by weight
Icing sugar.....2 parts by weight.
Rye flour.....2 parts by weight.

The bait should be scattered along the concrete or wooden sides of the beds and as soon as it becomes encrusted, a fresh supply of the mixture should be used. Some growers have claimed that the two baits recommended may be used to best advantage by changing every now and again from one to the other.

SLUGS

Several kinds of slugs are found in greenhouses and not infrequently important damage is effected to young and tender foliage of chrysanthemum, pansy, petunia, cucumber, and many other plants. These creatures, which of course are not insects but true molluscs, are often referred to by growers as snails. The species *Limax maximus* L., European in origin, is widely distributed. It has been found in greenhouses, in Ottawa, Ont., and Toronto, Ont. *Deroceras agreste* Linn. has caused injury to orchids at Langley Prairie, B.C. Other species of slugs which occur in Canada, and which are known to infest greenhouses are: *Arion hortensis* Ferussac, *Aspidophorus* (*Milax*) *gagates* Drap., and *Testacella haliotoidea* Drap.[1]

DESCRIPTION AND HABITS

Slugs are slimy, soft-bodied creatures, usually of a dark greyish colour and in length varying from one-half to three or four inches. They are nocturnal in habit, hiding during the day beneath clods of earth, etc. They feed freely on the foliage of plants and where they have been working a slimy trail is left which, when dry, is shiny and easily noticed.

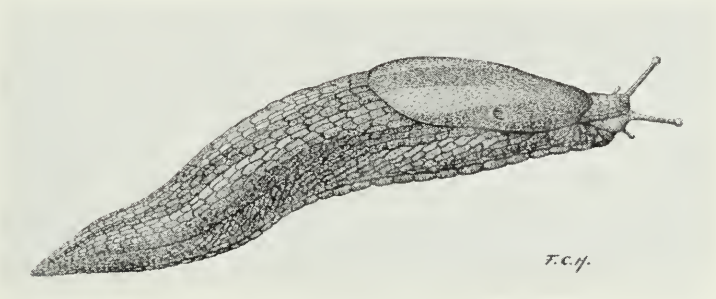


Fig. 40.—Slug, enlarged (authors' illustration).

Food Plants.—As already mentioned, various kinds of plants are attacked; chrysanthemum, marigold, snapdragon, etc. In one year, serious injury was effected to cineraria, coleus and geranium plants in a large greenhouse in Montreal.

CONTROL

Hand Picking.—If the plants are examined at night, the slugs may be seen feeding and numbers removed from the plants by hand.

Traps.—Shingles placed throughout infested beds will attract the slugs, forming as they do suitable hiding places. If they are turned over in the morning, the slugs present may be easily destroyed by scraping them off and crushing them with the foot.

Dusts.—As they come out to feed in the evening an excellent remedy is to broadcast lightly over the soil before nightfall, freshly slaked lime. This adheres to their bodies and soon kills them. Two or three applications on consecutive evenings are advisable. Mr. Downes, Dominion Entomological Laboratory, Victoria, B.C. recommends a dust composed of dehydrated copper sulphate 1 part, hydrated lime 10 parts.

---

[1] Records furnished by A. LaRocque, Can. Nat. Museum, Ottawa.

Metaldehyde.—During recent years, a new remedy for slugs has come into prominence. This consists of a mixture of metaldehyde and bran which is offered for sale at most seed stores under a proprietary name. The mixture should be placed in small heaps within ten feet of the plants to be protected. If the infestation is general broadcast the mixture.

Fig. 41.—Method of protecting orchid blooms from slug injury (original).

Protective Measure.—In an orchid house at Langley Prairie, B.C., the valuable flowers have been protected from slug injury by fastening a band of cotton batting around each spathe, as shown in the illustration.

MILLIPEDES

Several species of millipedes or "thousand-legged worms", creatures related to insects, have commonly been found in numbers in greenhouses in Canada. Although millipedes are known to injure seedlings and to attack the roots of plants, it is well known that their natural food is decaying vegetable matter. It is their presence that is chiefly objectionable to growers. In this regard an interesting infestation of the greenhouse or hothouse millipede, *Oxidus gracilis* (C.L. Kock), occurred in a greenhouse in western Ontario. The worms were present in large numbers, but the owner of the house did not find that they injured any plants.

DESCRIPTION AND HABITS

Millipedes, in general, may be described as rather slender, worm-like, cylindrical creatures, with a hard surface. The life-history of these creatures

is by no means well known. In the case of the greenhouse millipede it is known that the females deposit whitish eggs in masses in the soil. A single female may lay as many as 300 eggs, which hatch in about three weeks. The young millipedes are, in general appearance, except in size, similar to the adults.

Fig. 42.—A common millipede (authors' illustration).

CONTROL

Dry Applications.—A mulch of tobacco dust about one-half inch to one inch deep worked into the soil has proved of special value. In British Columbia, soil insecticides containing naphthalene, according to W. Downes, have been observed to act as a deterrent when mixed with the soil around, but not touching, the plants. In England, a dressing of naphthalene at the rate of 2 to 3 oz. per square yard, watered in, is recommended.

Arthur Kelsall, in reporting on the control of the "greenhouse millipede" by means of a nicotine dust, reported that the dust was manufactured in a home-made ball-mill and contained 5 per cent nicotine sulphate and 95 per cent hydrated lime. Several tests were made by removing boxes and pots and dusting the pests before they could enter the soil. A complete kill of all millipedes hit with the dust was had on each occasion.

Wet Applications.—In Ontario, control has been secured by spraying seedling flats at night with a 40 per cent nicotine extract (1-400) after which the flats were covered with glass. In other experiments it has been found that drenching the beds with a similar mixture in the strength of 1 part to 700 of water has been of value.

Poisoned Bran Bait.—It is claimed by some writers that the poisoned bran bait mentioned on page 22 is attractive to millipedes if two additional quarts of molasses are added.

Traps.—Place pieces of potato dipped in a paris green solution among the plants, or lumps of dough sweetened with molasses poisoned with paris green.

THE ROOT-KNOT EELWORM, *Heterodera marioni (cornu)* Goodey.

Greenhouse plants, particularly tomatoes and cucumbers, are frequently injured by a microscopic worm known as the root-knot eelworm. The worm enters the roots from the soil and feeds upon the sap.

DESCRIPTION AND HABITS

Eelworms or nematodes are not insects but belong to a group of animals designated as "round worms". They occur in the soil as immature, thread-like worms, and, as previously stated, bore their way into the roots of plants. Within the root tissues they develop into males (minute elongate worms) and females (small pear-shaped bodies half the size of the head of a pin). Eggs are laid inside gall formations and the larvæ, which hatch from them, work their way out to the soil and attack other plants. The irritation of the tissues, caused by their feeding activities, results in the production on the roots of abnormal swellings or galls which vary greatly in size and shape (fig. 44). The injury to the roots naturally robs the plants of vigour, checks the growth, materially reduces the set of fruit, in the case of tomatoes, and, if severe, causes premature death.

FIG. 43.—Healthy cyclamen plant in pot at left; plant at right destroyed by eelworms (authors' illustration).

FIG. 44.—Tomato roots showing swellings, or galls, resulting from eelworm infestation (authors' illustration).

Food Plants.—The root-knot eelworm has almost a world-wide distribution and it is known to have over 500 host plants. In southern United States, it is a serious pest of truck and garden crops, but fortunately in Canada, although it is said to have been occasionally found out-of-doors in southern Ontario, it is only of importance as a greenhouse pest. It infests lettuce, cyclamen, violets, etc., but, under Canadian conditions, it is primarily a pest of tomatoes and cucumbers.

CONTROL

In view of the fact that the eelworms occur in the soil and survive over a considerable period, there are two possible ways of getting rid of them: (1) by changing the soil, or (2) by sterilizing the soil with steam as described herewith.

SOIL STERILIZATION

It is generally conceded that where live steam and other necessary facilities are available, the use of steam is the most satisfactory method of disinfecting the soil. Two methods of steam sterilization are generally used: one called the " inverted pan method," and the other " the tile method."

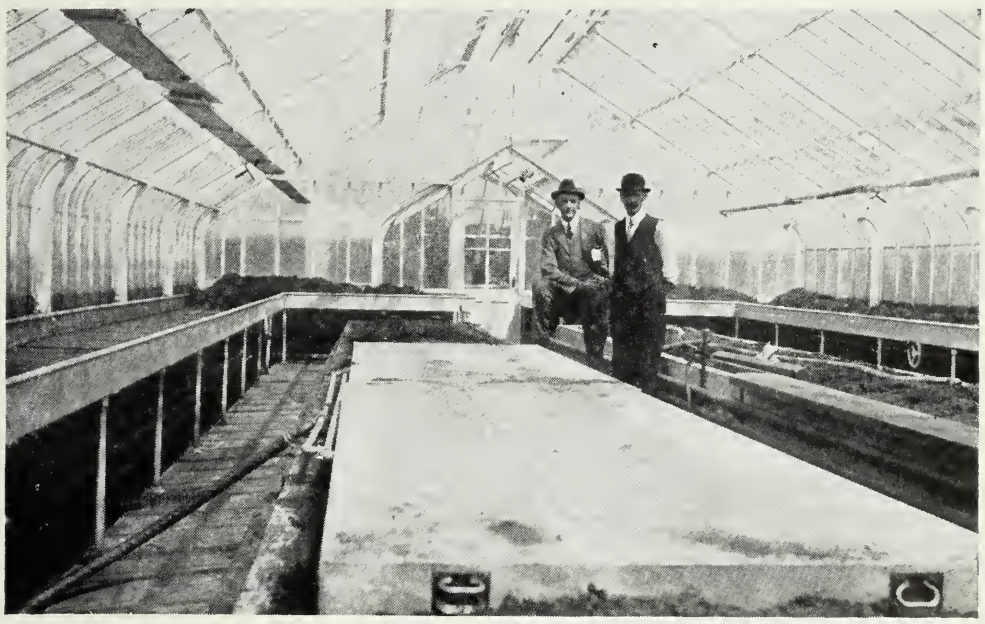


FIG. 45.—Showing inverted pan method of sterilizing soil (authors' illustration).

The Inverted Pan Method.—The apparatus used in connection with this system of soil disinfection consists of a galvanized iron pan, about 6 feet by 10 feet by 6 inches,[1] with sharp edges, with steam hose connections and with handles. In using it the sharp edges of the inverted pan are forced well into the soil and steam is then admitted. The steam should be maintained at as high a pressure as possible, 80 to 100 pounds, and the treatment should be continued for one or two hours depending on the pressure. The most convenient method of determining when the process of sterilization has gone far enough, is to bury potatoes in the soil at a depth of about one foot, and when they are thoroughly cooked, the steam may be turned off.

The Tile Method.—In this method, the steam with a pressure of at least 50 pounds, is run through four-inch tile laid 2½ feet to 3 feet apart and 1 foot deep, and the soil covered with paper or sacking to retain the heat. The steaming should be continued for some eight to ten hours, or until potatoes placed near the surface are cooked.

[1] The exact size of the pan should be determined by the dimensions of the beds.

Steam sterilization not only eradicates nematodes, but it also rids the soil of all insect life, of pests such as sowbugs, of injurious fungi such as those which cause damping-off, lettuce drop and *Rhizoctonia,* and of weed seeds. It also has the advantage of improving the soil conditions and, for this reason, it is said that sterilized soil requires less fertilizer than untreated soil.

It is an excellent practice to destroy by burning all tomato or cucumber plants after the crop has been harvested.

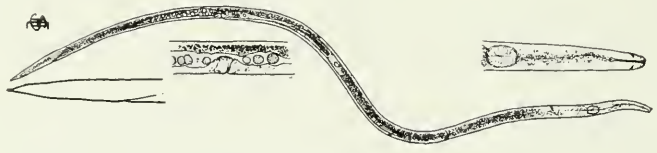


FIG. 46.—Foliar nematode, *Aphelenchoides olesistus* R. Bos; separate drawings showing details of anatomy; all much enlarged (authors' illustration).

FOLIAR NEMATODE

Occasionally nematode or eelworm attack upon the leaves of greenhouse plants has been found, particularly on ferns (*Pteris* spp.). On such plants, large brownish-coloured areas were present on the fronds of young plants, due to the presence of eelworms.

In 1915 a fern infested with eelworm (*Aphelenchoides olesistus* R. Bos) was received from Hamilton. This was placed in a greenhouse and with ordinary attention outgrew the injury.

FIG. 47.—Fern leaves injured by foliar nematode *Aphelenchoides olesistus* R. Bos (redrawn after Marcinowski).

The discoloration of the fern fronds as shown in fig. 47 is the result of the presence of the eelworm. Goodey, in the publication referred to, states that in begonias the attack generally appears first toward the edge of the leaf in between the veins, and spreads inwards towards the stalk. The infected parts turn a pinkish-yellow tint and appear more transparent than the healthy parts. In addition to ferns and begonias, a large number of other plants are known to have been attacked by this eelworm.

CONTROL

The following general recommendations may be given: (1) the use of pots washed in hot water; (2) partial sterilization of potting composts; (3) the placing of plants on staging so that the foliage does not touch or intermingle thus allowing water to fall from plant to plant; (4) the quarantining of plants for observation purposes before placing in houses free from disease.[1]

[1] Goodey, T., Plant Parasitic Nematodes, London, 1933.

THE CYCLAMEN MITE, *Tarsonemus pallidus* Banks.

During recent years great difficulty has been experienced in growing cyclamens successfully, owing to the depredations of the cyclamen mite. Mite injury was noticed in Ontario as early as 1908, but apparently there was no serious outbreak of the pest until 1916, at which time attention was first directed to it. That year it caused severe injury to cyclamens in several Ontario greenhouses, and since then it has been decidedly troublesome, not only in the Province of Ontario, but also in the Provinces of Quebec and British Columbia.

In the United States, the mite was first noticed in New York State in 1898, at which time it was named and described. Since then it has been recorded from many states and no doubt occurs wherever cyclamen stock is grown.

Fig. 48.—Cyclamen bloom destroyed by the cyclamen mite; healthy bloom at right (authors' illustration).

DESCRIPTION AND HABITS

The adult mites are pale, shiny-brown, ovate creatures with four pairs of legs. They are about 0·2 mm. or 1/125 inch in length. The immature forms are translucent and have only three pairs of legs. The eggs are oval, hyaline bodies about 0·12 mm. x 0·06 mm. All stages are barely visible to the naked eye.

The mites, in all stages, occur on the tender foliage, on the buds, and on the bloom. They will attack almost any part of the flower—the petals, stamens and ovary, but as a rule, most of them are found between the calyx and corolla.

Food Plants and Injury.—In addition to cyclamen, the mite is a pest of chrysanthemum, begonia, snapdragon, fuchsia, delphinium and geranium.

On cyclamens the mite produces what florists usually term the "cyclamen disease." Attacked flowers become distorted, blotched, streaked and flaccid in appearance and die prematurely. In many cases, the flower buds do not open but gradually wilt and die. Infested foliage becomes curled, and at the point of attack little depressions or pockets may be found, and the leaf epidermis may assume a dark, purplish and cracked appearance. Badly injured cyclamens are absolutely worthless.

CONTROL

Experiments conducted in the United States and in Ontario have demonstrated that all stages of the mite may be destroyed by immersing the infested plants, pot and all, in water at a temperature of 110 degrees F. for 15 to 20 minutes, and that this treatment is the only really effective method of preventing mite injury. In the case of cyclamens—the plants which are most subject to mite infestation—a regular practice should be made of treating all the plants with hot water before the flower buds appear. Care must be taken to maintain the temperature of the water at 110° F., as higher temperatures may injure the plants, and lower temperatures may not kill all the mites. The plants should be shaded for about 24 hours after treatment.

THE BULB MITE, *Rhizoglyphus hyacinthi* Boisd.

Shipments of bulbs arriving in Canada from Europe have been found to be noticeably infested by the bulb mite. This mite is abundant in several European countries and has also been found in the United States on bulbs imported from Japan and the Bermuda Islands.

FIG. 49.—Tulip bulb infested with the bulb mite; outside layer of bulb turned back to show feeding places of mite (authors' illustration).

DESCRIPTION AND HABITS

The mite is very small and can hardly be seen without the aid of a good lens. It is whitish in colour, frequently with a pinkish tinge. The mite may be present on the bulb in all stages—egg, larva, nymph, and adult. On hatching from the egg, the larva bears six legs. After feeding for a short time, this six-legged larva becomes inert and moults. The new form has eight legs and is known as a nymph, and it is during this stage that the greatest growth takes place. Larva, nymph, and adult do not differ greatly from one another in external appearance[1]. Important signs of infestation are: the checking of the growth of the plants, the leaves turning yellowish; failure of the plants to produce flowers; and the presence of reddish-brown spots on the scales of the bulb indicating the feeding places of the mites.

Food Plants.—The bulb mite has been found in Canada commonly on imported narcissi, hyacinth and tulip bulbs and in the greenhouse on Easter lily bulbs.

CONTROL

Infested bulbs should be treated by the hot water method (see page 66), immersing them for two and one-half hours at 110° F.

EARTHWORMS

Generally speaking, earthworms are beneficial. By burrowing here and there and by feeding on the soil they have the effect of breaking up the soil and of making it more accessible to air, moisture, bacteria and the roots of plants. Occasionally, however, in heavily manured greenhouse beds they become so numerous that they are a decided nuisance.

CONTROL

Earthworms may be killed by a light dressing of hydrated lime worked and then washed into the soil.

Where it is not advisable to use lime, the worms may be kept down to small numbers by watering with a solution of corrosive sublimate—1 ounce dissolved in a small quantity of hot water and diluted to 10 gallons of water. Since corrosive sublimate corrodes all metals, earthenware or wood containers should be used for the solution. All containers should be washed thoroughly after usage.

SPIDERS

Spiders of various kinds are commonly found around and in greenhouses, spinning their webs in places little disturbed. While most people dislike spiders it should be remembered that their food consists of flies and other soft-bodied insects, therefore they should be considered to be beneficial rather than otherwise. With rare exceptions spiders are in no way harmful to humans. Even when handled, spiders which occur in Canada usually do not bite. In any event, the bites of most species are not to be compared with that of the mosquito. One species, however, has been found recently in various parts of Canada, notably in the West, which is to be feared on account of the definitely poisonous character of its bite. This is the black widow spider, *Latrodectes mactans* Fab. It is a small black spider with red or yellow markings. The most constant of these markings is one shaped like an hour-glass on the underside of the abdomen (fig. 50). The venom of the black spider is rapid in its action, and pain

[1] Leaflet 136, Board of Agriculture and Fisheries (London, England).

may be felt within a few seconds after the bite. This pain may gradually spread over the body, and the larger muscles may become sore and rigid, with occasional spasms. The pain reaches its maximum in 1 to 3 hours, continues from 12 to 48 hours, and then gradually subsides. A person who is bitten should be put to bed, kept as quiet as possible, and given plenty of water to drink. The site of the bite should be painted with a local antiseptic such as iodine, to prevent secondary infection. A doctor should be called immediately.

Fig. 50.—Female black widow spider, dorsal and ventral views; much enlarged (after Gibson and Twinn).

Regarding the control of spiders, owing to their generally beneficial habits their wholesale destruction is not recommended. In and around greenhouses all that may be necessary usually in the way of control would be to sweep away the webs. If, however, more drastic action is desired, spray the places infested by the spiders with a spray made as follows: Add from one-half to one pound of pyrethrum insect powder to one gallon of kerosene, and agitate the mixture at intervals over a period of about two hours (or longer), to ensure the extraction of the active principles of the pyrethrum. The residue of the pyrethrum settles to the bottom of the vessel as a brown sediment, and the clear liquid, which is pale lemon-yellow in colour, may either be siphoned or filtered off. The spray should be kept in a tightly corked container and protected from sunlight, to prevent it from deteriorating in strength. There are a number of proprietary fly sprays on the market similar in composition to the one described which may be substituted for it by those who wish to avoid the trouble of preparing their own spray material.

NATURAL CONTROL[1]

In addition to the insect pests against which the grower must be continually on guard, there are a large number of insects that are entirely beneficial in their relation to agricultural crops. The production of many field crops would be much more expensive, if not impossible, without the assistance of these unobtrusive allies.

The artificial conditions created in a greenhouse frequently exclude these beneficial insects or interfere with their normal activities to such an extent that they are of little value. The reverse should be true, however, since the greenhouse conditions can be controlled so as to give the natural enemies every advantage, and if their habits are carefully studied the grower can do much to reduce insect losses.

There are two groups of beneficial insects with which the grower should be familiar, and a few examples of these are given herewith.

EXTERNAL PARASITES OR PREDATORS

Fig. 51—Two-spotted ladybird beetle, *Adalia bipunctata* L. enlarged and natural size (after Gibson and Twinn).

Fig. 52—Larva of ladybird beetle, enlarged about three times (after Ross).

Ladybird beetles are among the most common of all beneficial insects. There are many species, all of which, both in the larval and adult stages, feed on aphids and other small insects. The adults are oval in shape and often brightly coloured in various combinations of red, white, yellow or black. The larvæ are less conspicuous than the adults, but can usually be found crawling about among the colonies of aphids during the spring and summer. They are voracious feeders and dispose of colonies of aphids in a short time. The eggs are lemon or orange coloured and are laid in clusters on the undersides of leaves. One species (*Stethorus punctum* Lec.) is entirely black, and about the size of the head of a match. This species feeds exclusively on all stages of the common spider mite.

The green lacewing and brown lacewing flies are four-winged insects with comparatively large transparent wings which are held roof-shaped over the body. The larvæ of these insects are called "aphis lions," although they feed on a great many kinds of insects in addition to aphids. They resemble somewhat the larvæ of ladybird beetles, but may be distinguished from them by

[1] Prepared by A. B. Baird, Dominion Parasite Laboratory, Belleville, Ont.

the fact that the body is spindle shaped and the head is equipped with long pincer-like mandibles. The eggs are readily identified, being placed on the plants at the tip of a silken stalk about half an inch in length.

Fig. 53.—Syrphid larva feeding on aphids (authors' illustration).

Another family of insects that is distinctly beneficial is the Syrphidae. The adults are brightly coloured two-winged flies that are sometimes called hover flies due to their habit of hovering over flowers or plants on which there are colonies of aphids. The larvæ are slug-like and crawl about among the aphids upon which they feed. The eggs are white and are usually laid in or close to aphid colonies. Other insects whose larvæ are aphid feeders include a small silvery-grey two-winged fly, *Leucopis,* and midges that resemble small mosquitoes. The larvæ of the latter insects are small but conspicuous due to their bright orange or red colour.

Predaceous mites and spiders are also of considerable importance in controlling injurious pests.

INTERNAL PARASITES

This group of beneficial insects includes numerous two- and four-winged flies that deposit their eggs in or on their hosts upon which they complete their development. They are less conspicuous than predators due to the fact that the adults are usually smaller, and in many cases the larvæ complete their

development within their hosts. For this reason, these insects may be present and actually controlling an insect pest in a greenhouse without the operator being aware of their presence.

The most common group of internal parasites that are found in greenhouses are those that attack aphids. The adults are small, dark-coloured, four-winged flies. Their eggs are deposited inside the aphids and the resulting larvæ devour the entire body contents as they complete their development. At this time the body shell of the aphid gradually hardens and becomes either straw-coloured or black, depending upon the species of parasite. After the parasite has completed its development, it cuts a circular hole in the top of the aphid shell and crawls out to continue its good work. Temperature is a most important factor in regulating the effectiveness of aphid parasites. If the mean daily temperature is 65° F., the parasites will usually increase more rapidly than the aphids and control can be expected.

Parasites of the mealybug and greenhouse whitefly have been introduced into many greenhouses in Canada. These are very minute insects, the larvæ of which are internal feeders. As in the case of aphid parasites, they are most effective when suitable temperature conditions are provided. Other important greenhouse pests are attacked by parasites also and these should be recognized and their development fostered wherever possible.

ANTIDOTES FOR POISONS

Several compounds poisonous to humans are recommended in this publication for controlling insects. These poisons are listed below, together with the antidotes for use in cases of emergency. Emetics referred to may consist of a large teaspoonful of ground mustard and, or, a like quantity of common table salt in a tumblerful of warm water, repeated as necessary. *In all cases of poisoning send for a doctor immediately.*

Arsenic.—Lead arsenate, paris green, white arsenic, sodium arsenate and sodium arsenite.—Give a prompt emetic, or use syphon tube cautiously inserted. Administer large draughts of warm milk and water, raw eggs, hot water with olive oil, melted butter, limewater, or magnesia in water; also tablespoonful doses of hydrated ferric oxide, if available. Apply warmth.

Calcium Cyanide.—If possible, cause immediate vomit; use syphon tube with permanganate solution 60 grains to two gallons of water, or emetics. Put cold applications to the head and neck; dash cold water on the face; place hot water bottles at feet and sides of the body. Apply smelling salts (ammonium carbonate). Give aromatic spirits of ammonia, brandy or whisky, one teaspoonful in a little water every 5 to 15 minutes by mouth (double quantity by rectum). Prevent sleep; apply artificial respiration. (See also under hydrocyanic acid gas.)

Corrosive sublimate.—No emetic. Give white of raw egg and milk in large quantities.

Dichlorocthyl ether.—Remove patient's clothing and place him in a well-ventilated but not cold room; wash eyes with boric acid solution (1 teaspoonful to a pint of tepid water); apply external heat; give whisky or strong tea; plenty of fresh air is essential.

Fluorides.—Sodium fluosilicate, sodium fluoride.—Give an emetic to cause the patient to vomit, followed by limewater, milk of magnesia, or a 1 per cent solution of calcium chloride. If these are not available, hydrated lime in water, or even ground wall plaster may be given.

Hydrocyanic Acid Gas.—Give neither alcohol nor emetics. Remove patient into the fresh air, loosen clothing, but protect from chill by wrapping in warm blankets. Apply artificial respiration if the breathing has stopped. (See also under cyanides.)

Kerosene and other Hydrocarbons.—Same as under rotenone.

Metaldehyde.—Induce vomiting with mustard and warm water. Drink plenty of milk. Take a large dose of castor oil.

Paradichlorobenzene.—Give an emetic, one tablespoonful of mustard in a glass of warm water, followed by a large dose of epsom salts.

Rotenone (Roots of *Derris* and *Lonchocarpus*).—Emetic such as salt or mustard in warm water, or stomach tube; keep patient warm; give stimulants—strong tea or coffee.

Sulphuric acid.—Give no emetic. Have the patient drink freely of concentrated lime water, calcined magnesia in milk or water, chalk in water, milk of magnesia, baking soda, washing soda, or soap suds, followed by raw eggs, milk, or sweet oil.

Tobacco extracts.—Nicotine sulphate, etc.—Give an emetic, or evacuate the stomach with syphon tube, using plenty of water. Put the patient to bed, and give strong coffee or tea, and charcoal mixed with water, freely. Apply warmth to the feet and sides of the body. Use artificial respiration if necessary.

INDEX

OTTAWA
J. O. PATENAUDE, I.S.O.
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1940